

MACWA Marsh Futures: Assessment and Mapping of Salt Marsh Vulnerabilities to Guide Restoration at the Local Scale

Danielle Kreeger, LeeAnn Haaf & Angela Padeletti

Partnership for the Delaware Estuary

Martha Maxwell Doyle & Erin Reilly

Barnegat Bay Partnership

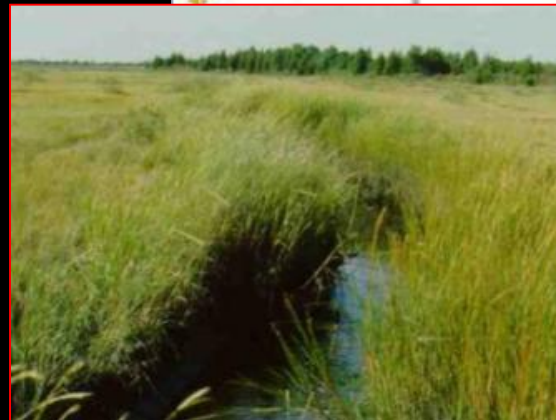


Coastal Wetlands

Abundant
Diverse

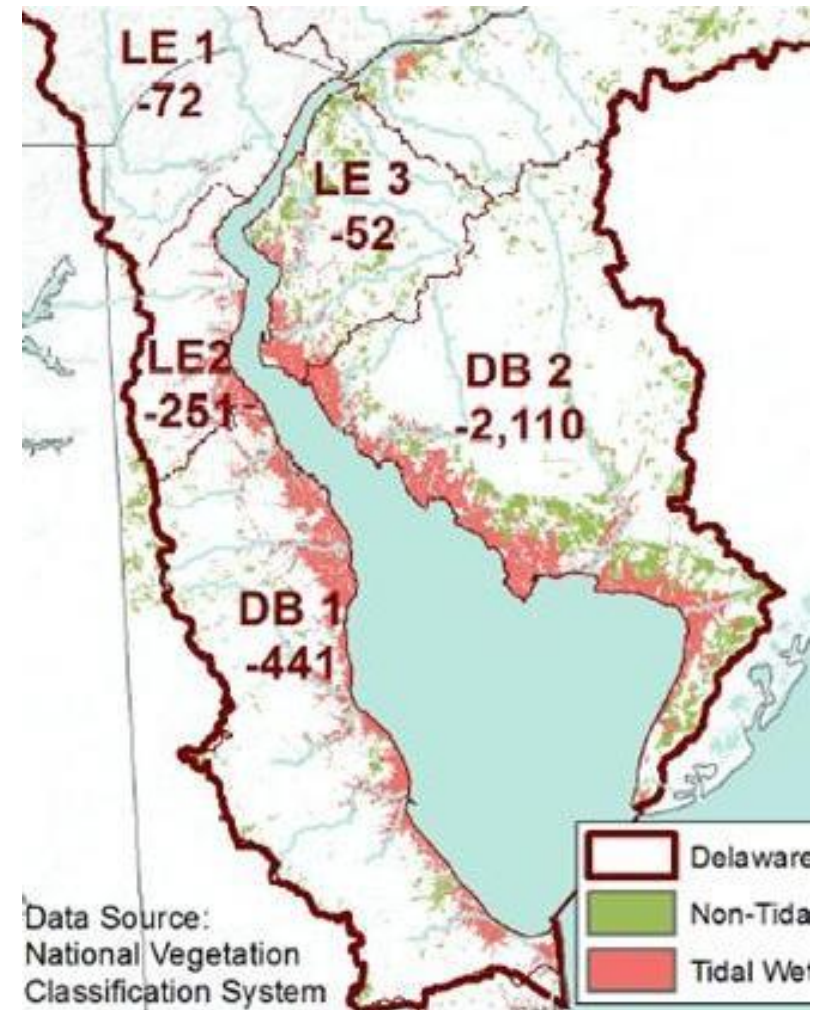
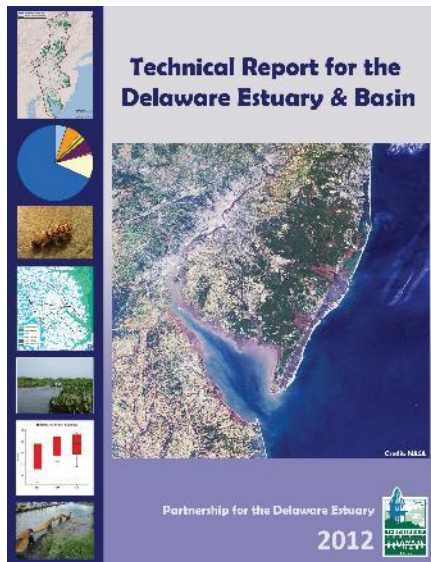
Benefits:

Flood Protection
Water Quality
Fish and Wildlife
Natural Areas
Carbon Capture



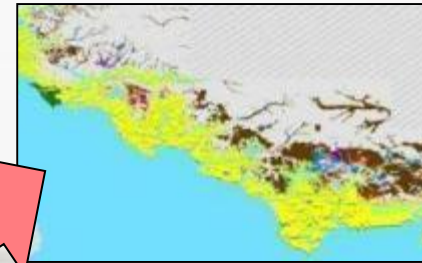
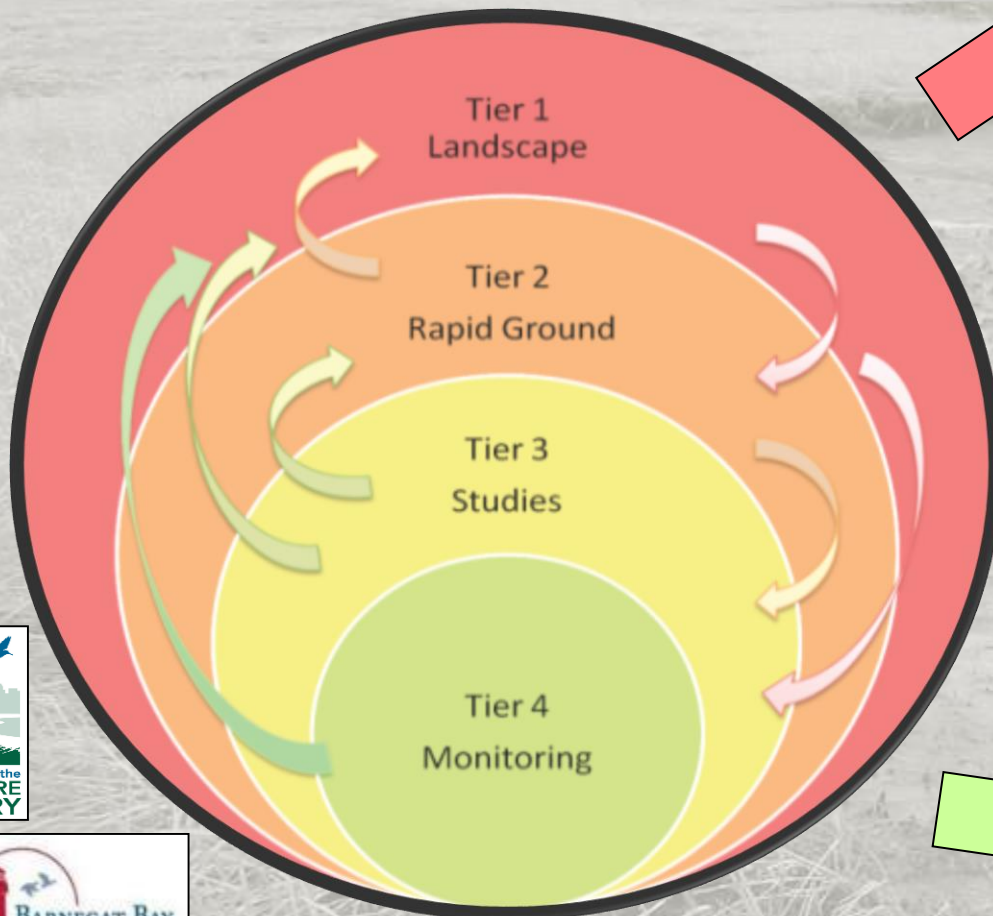
Coastal Marsh Declines

- Losing ~1 acre per day in the Delaware Estuary
- Losses due to various stressors



The Mid-Atlantic Coastal Wetland Assessment

Integrated monitoring of tidal wetlands for water quality, habitat management, and climate/restoration planning



Remote Sensing



Ground-Truthing



Intensive Studies



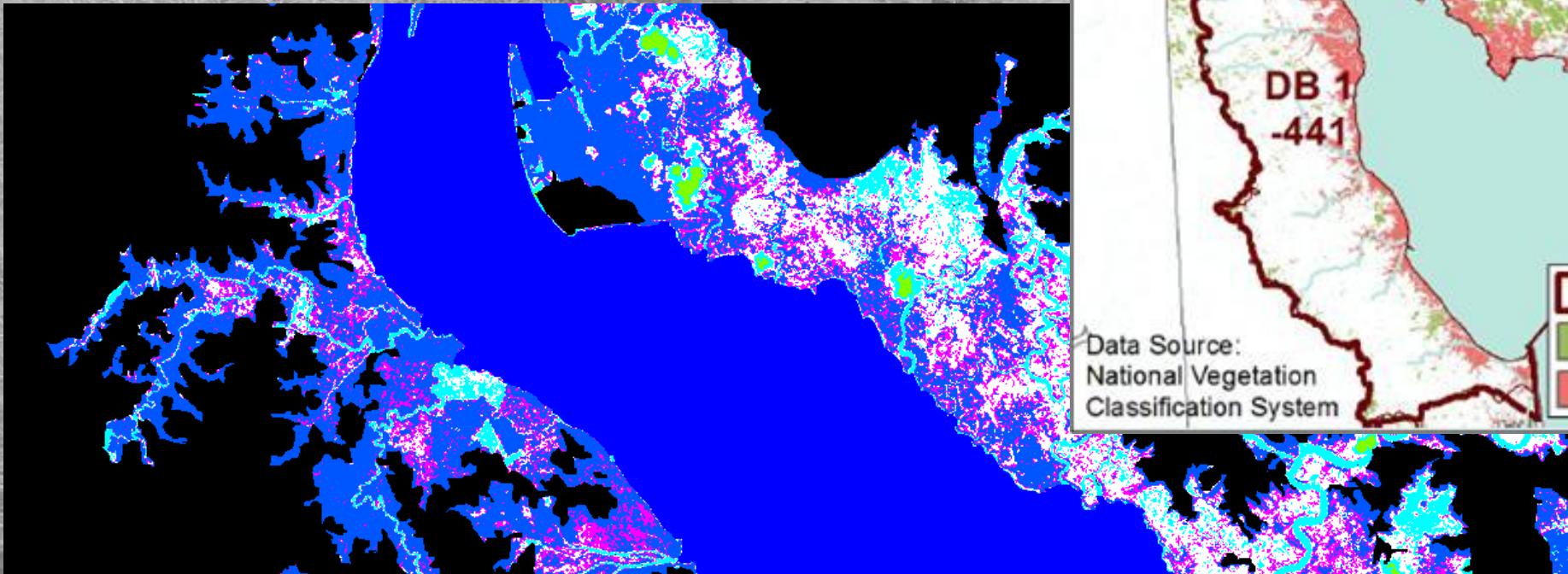
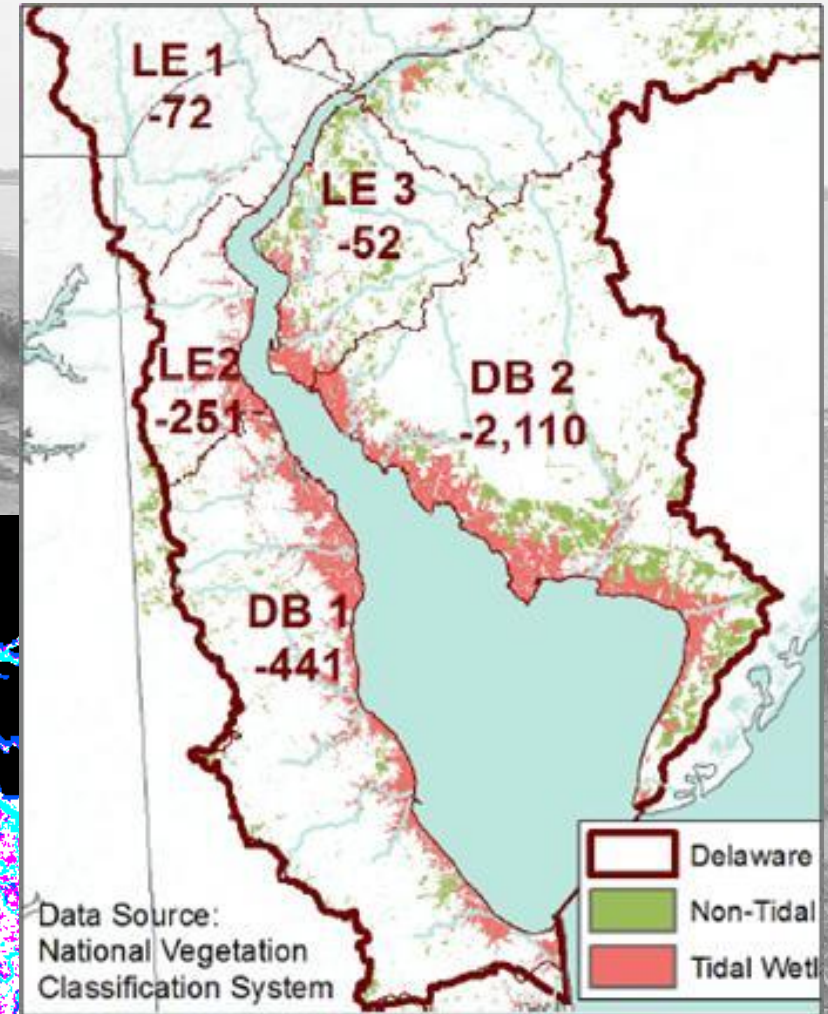
Station Monitoring



THE ACADEMY
OF NATURAL SCIENCES
of DREXEL UNIVERSITY

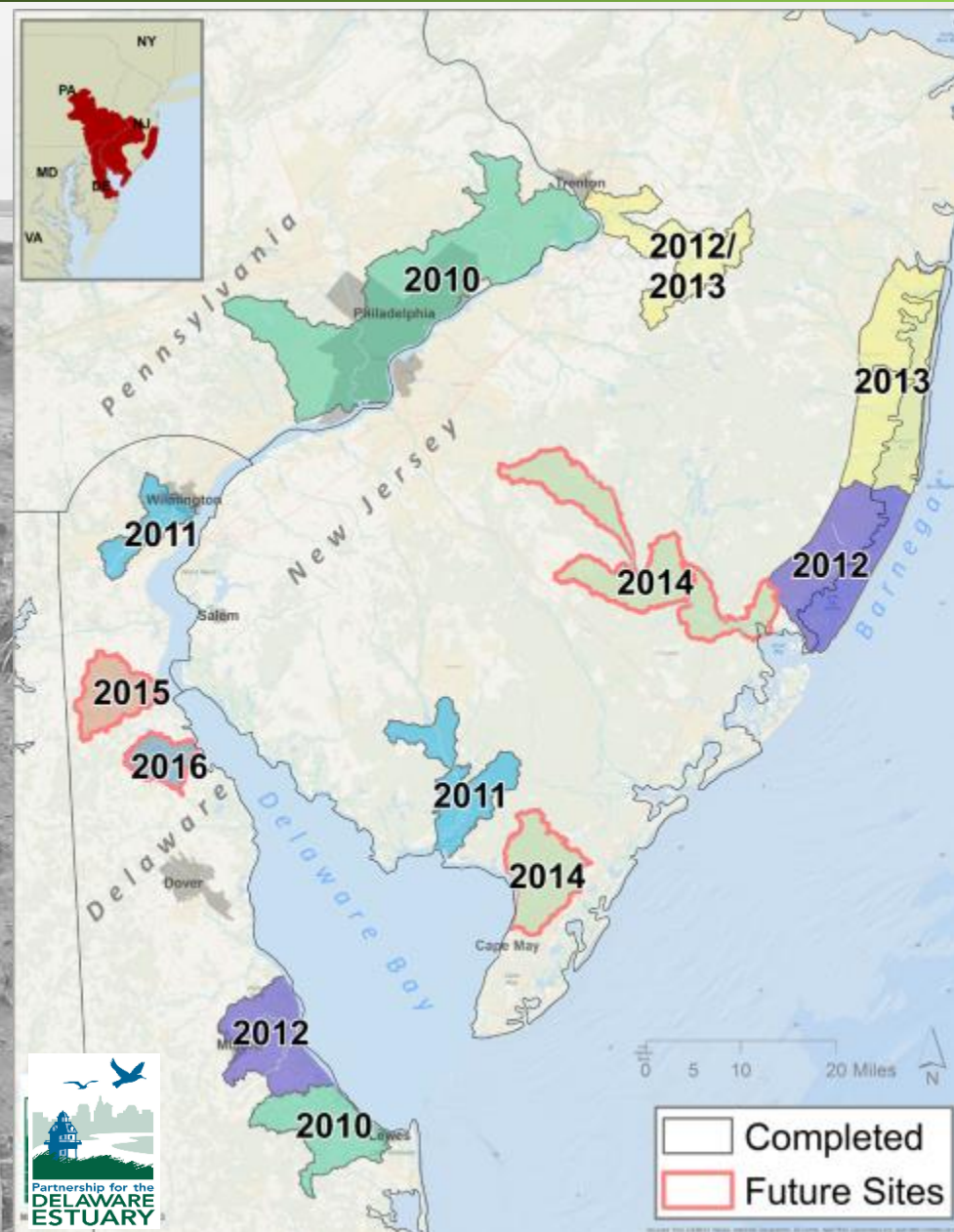
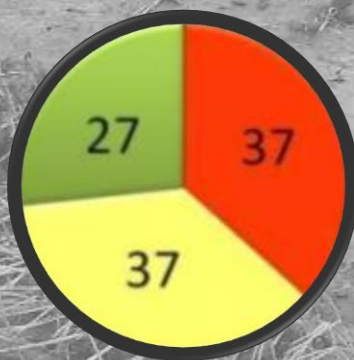
Tier 1 – Landscape Census

- NWI, NVCS etc.
- Land Use – Land Cover
- Aerial imagery



Tier 2 – Rapid Assessments

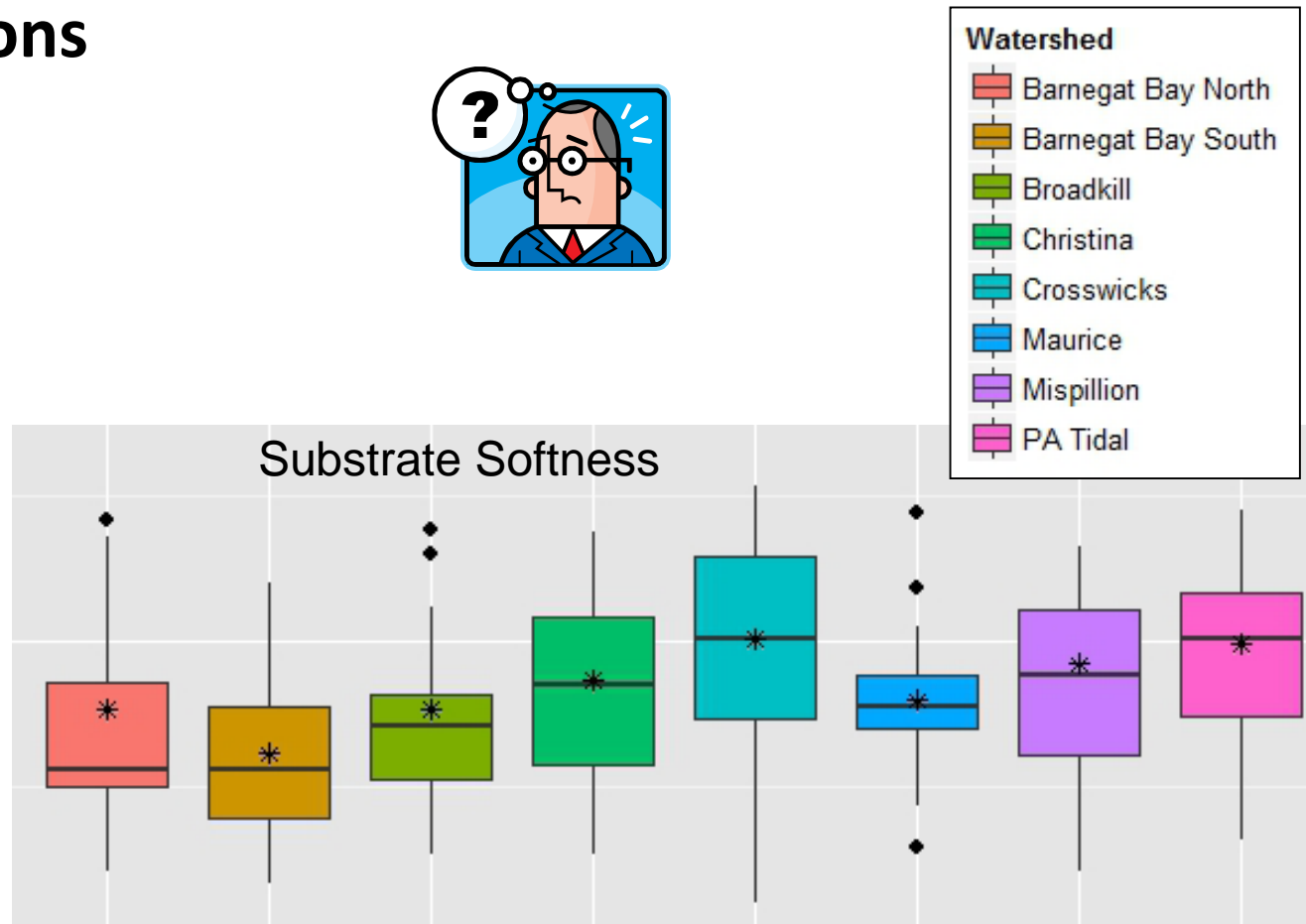
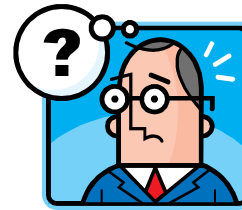
- PDE/BBP/DNREC has assessed the condition of >400 points since 2010 (*Mid-TRAM*)



Tier 2 – Rapid Assessments

**Stressor-response relationships vary widely,
with lots of interactions**

- Hydrology alterations
- Mosquito ditching
- Nutrient loadings
- Fill, Point sources
- Marine debris



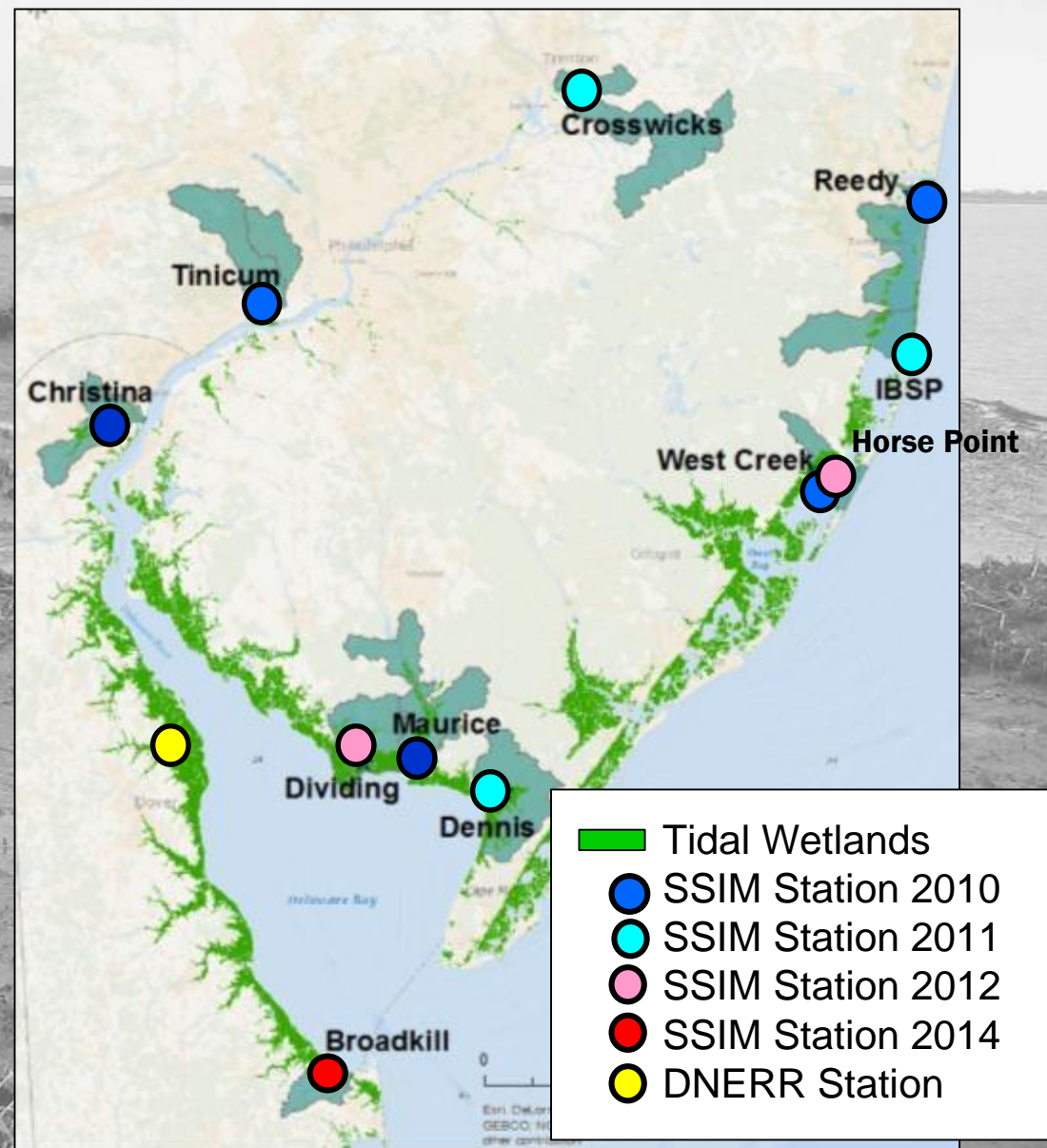
Tier 3 – Intensive Studies

- Vulnerability assessments
- Ecosystem service studies
- Restoration tactic R&D
- Restoration targeting



Tier 4 – Station Monitoring

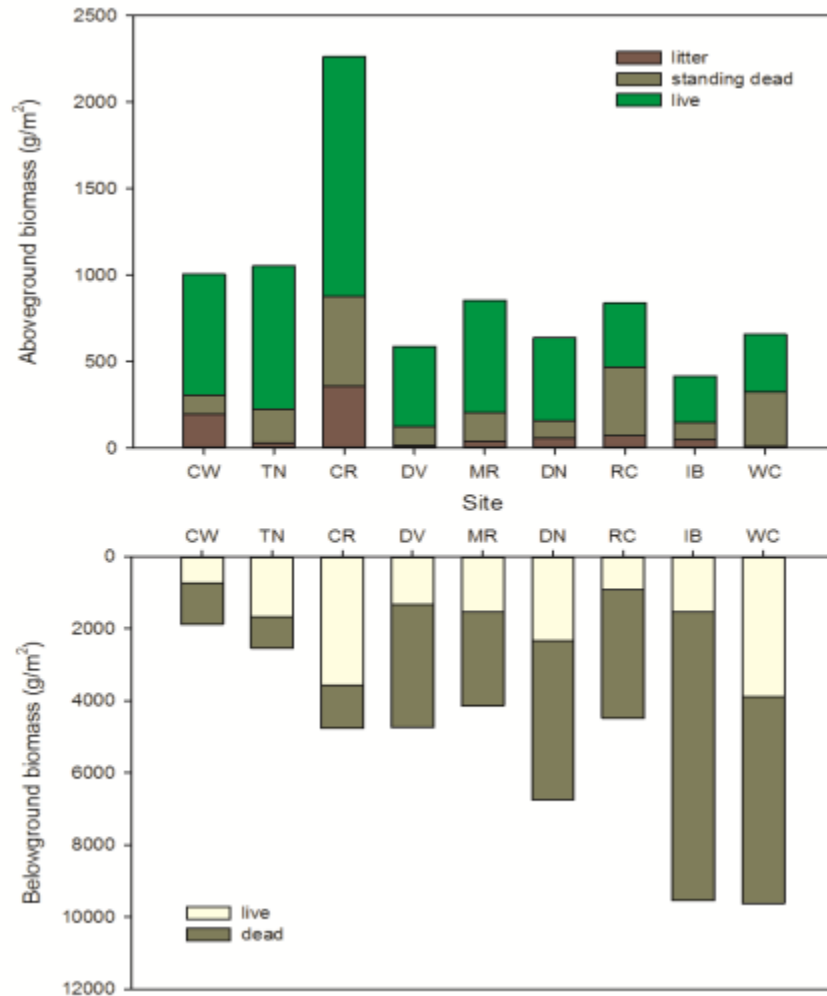
- 11 Stations installed
- Physical, chemical, biological



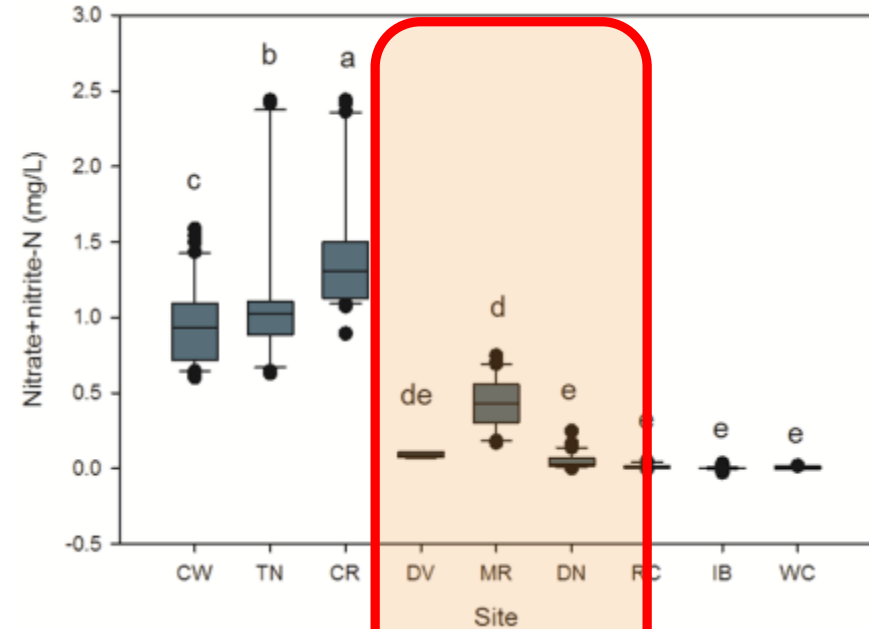
Interesting Patterns

Are nutrient loadings affecting ability to keep pace with SLR?

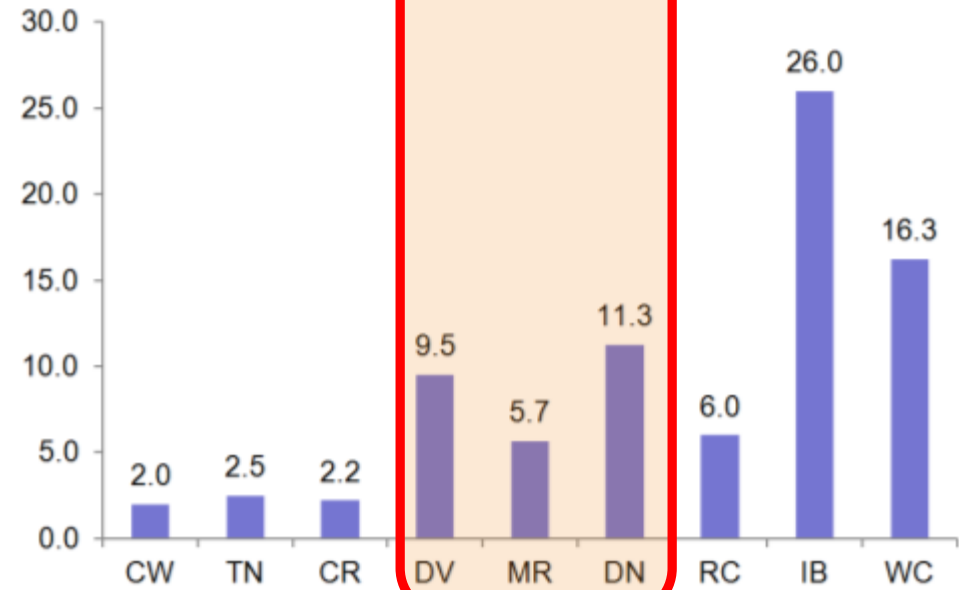
AG & BG Biomass



Tidal Creek Nutrients



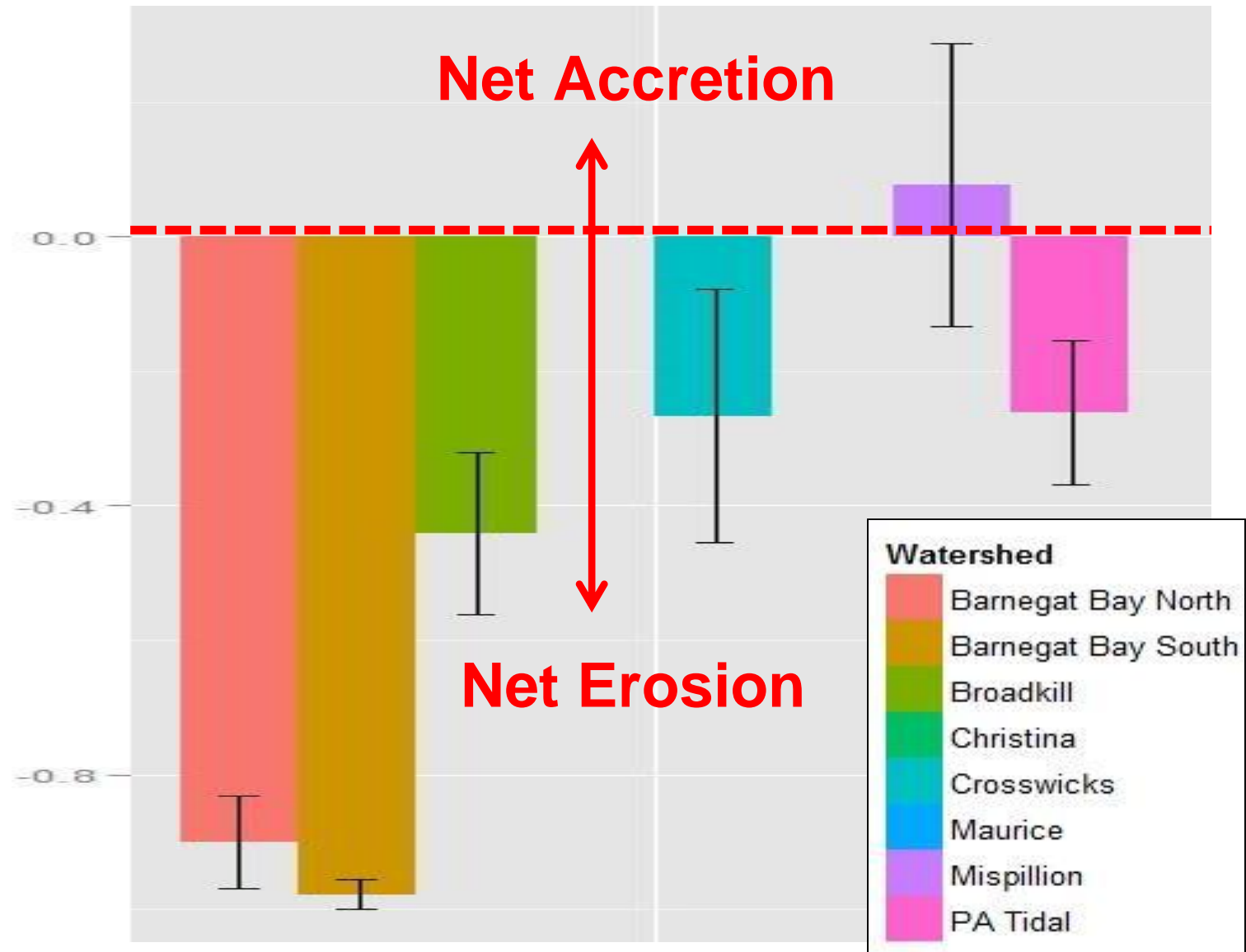
BG:AG Ratio



Erosion vs. Accretion

Majority of
marshes are
net eroding

*from Tier 2
rapid
assessments,
shoreline metric*

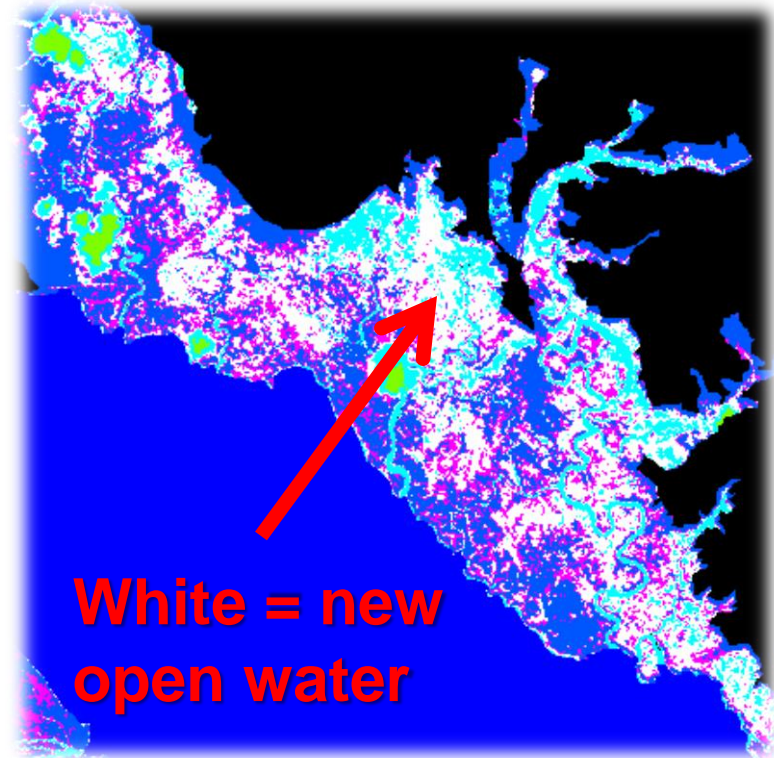


Two Decline Patterns

Edge Erosion (Horizontal)



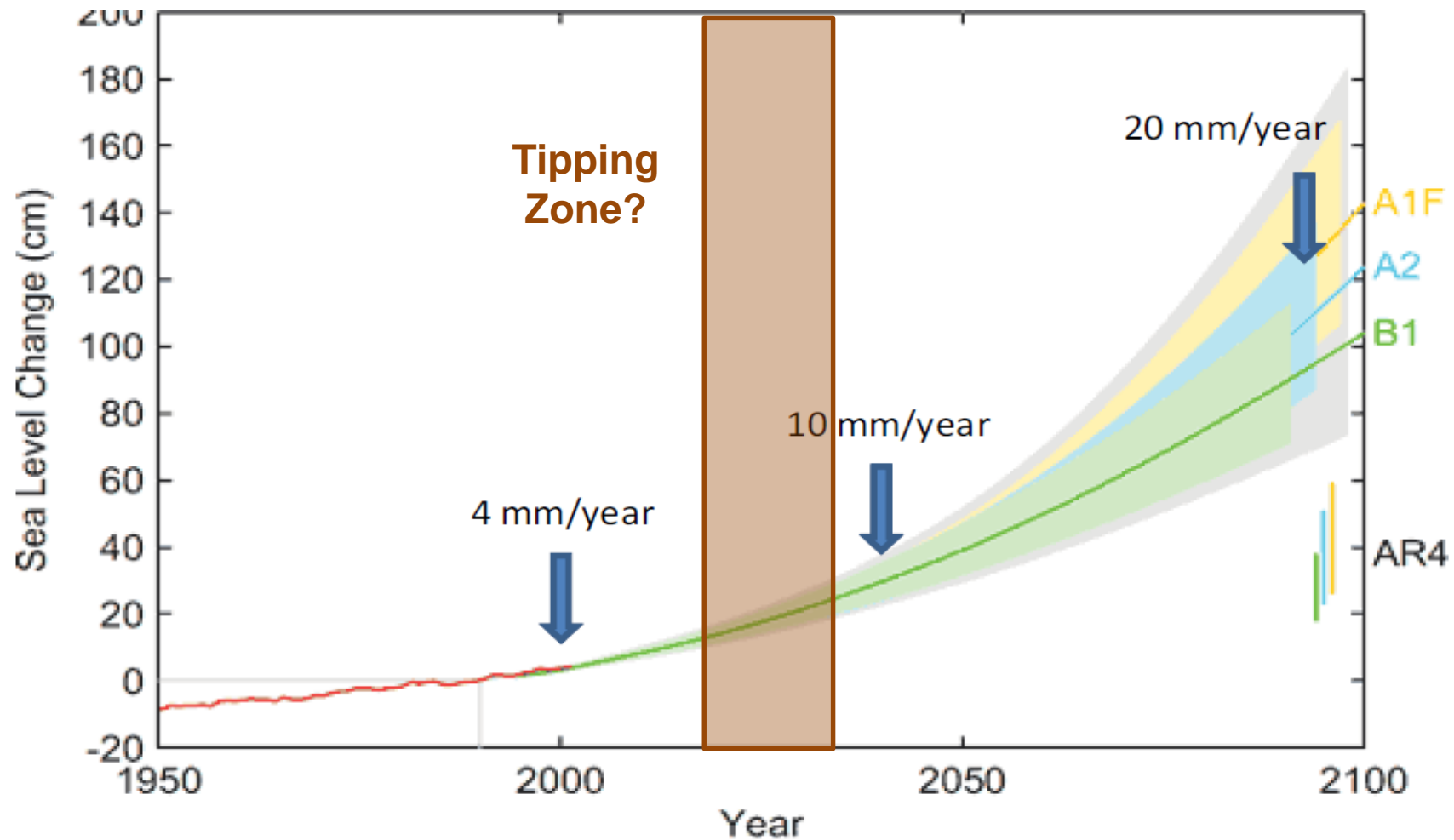
Interior Drowning (Vertical)



**White = new
open water**

Source: Riter and Kearney 2009

Future Challenges



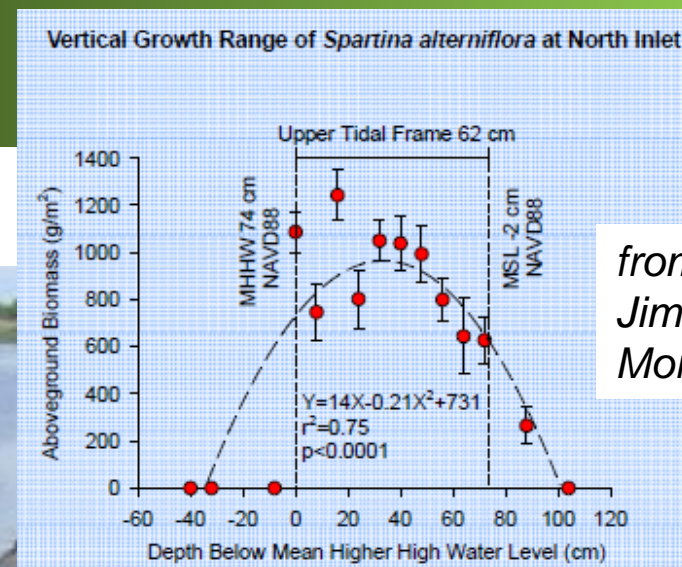
Most Salt Marshes Cannot Survive When Sea Levels Rise >1 cm Per Year

MACWA Reference Data

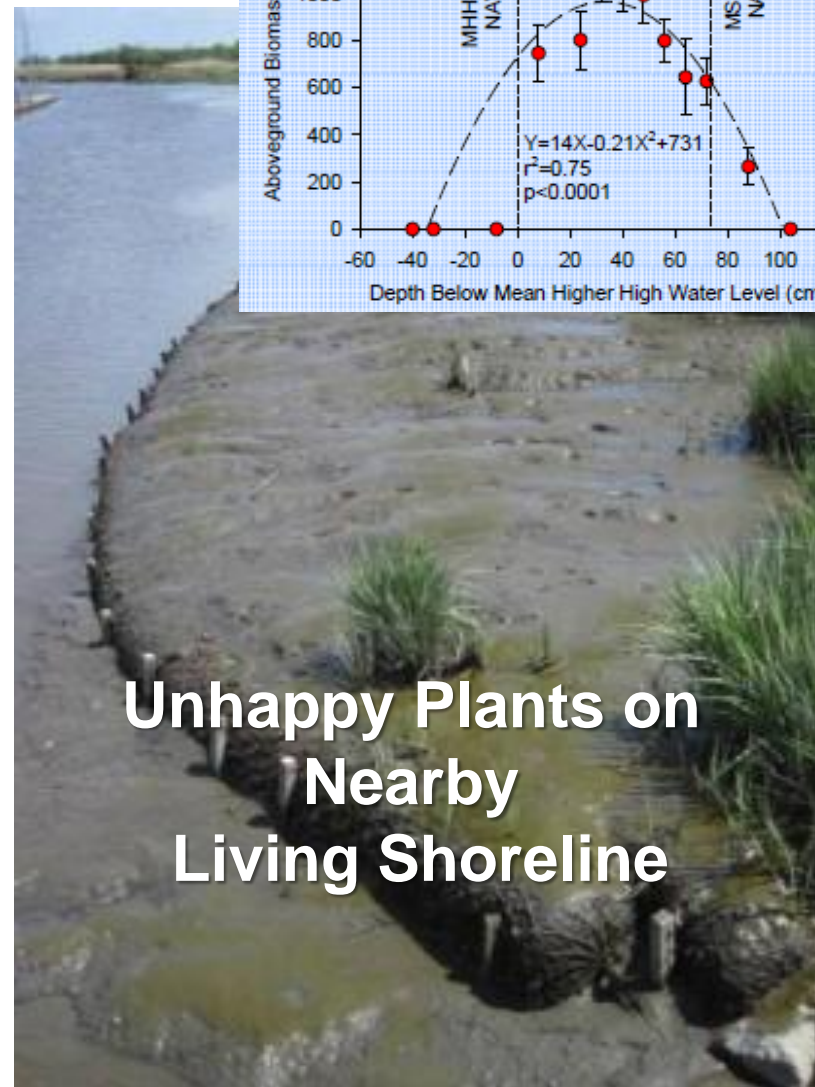
10 cm difference in elevation



Happy, Healthy Plants on
Living Shoreline

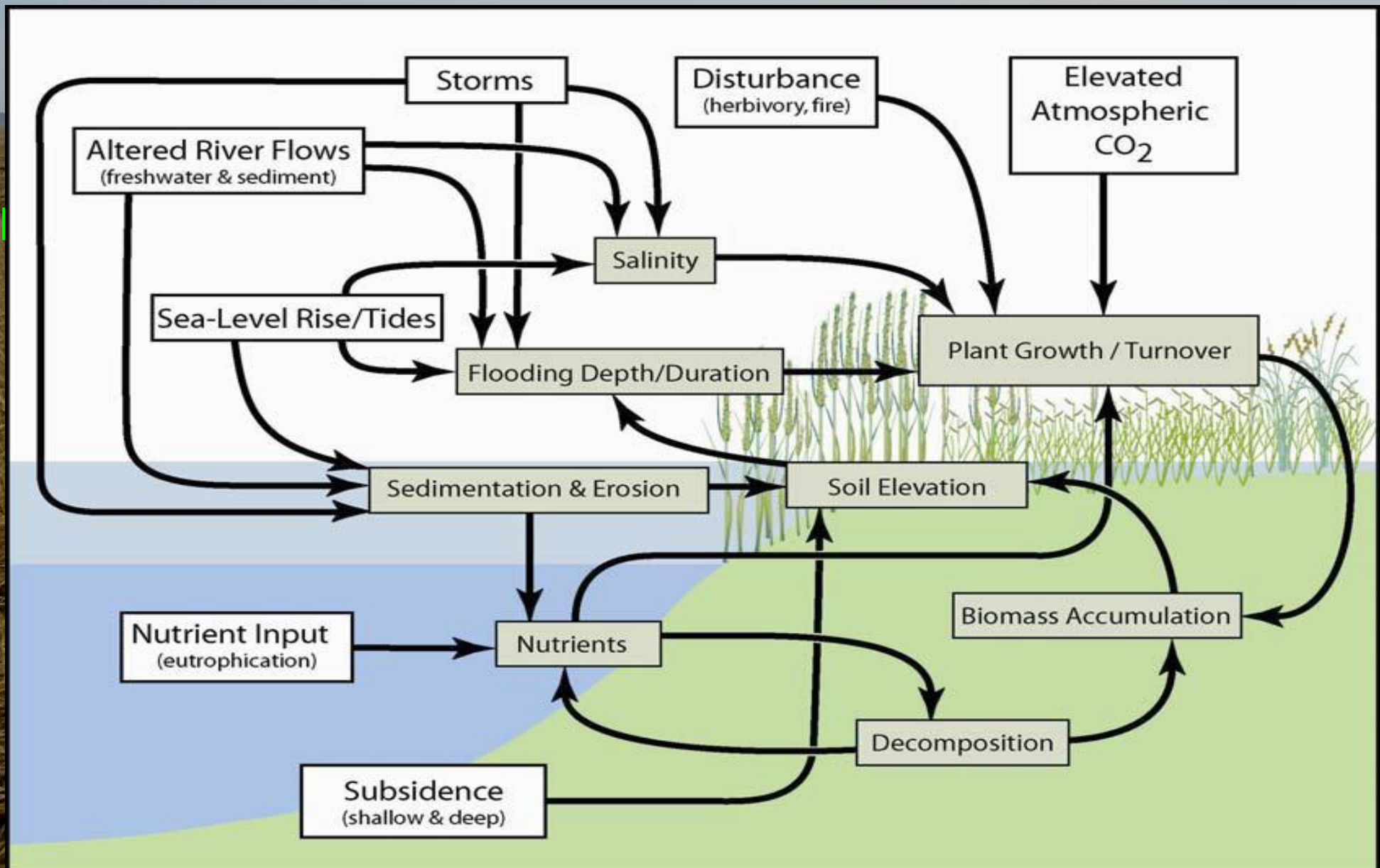


from
Jim
Morris

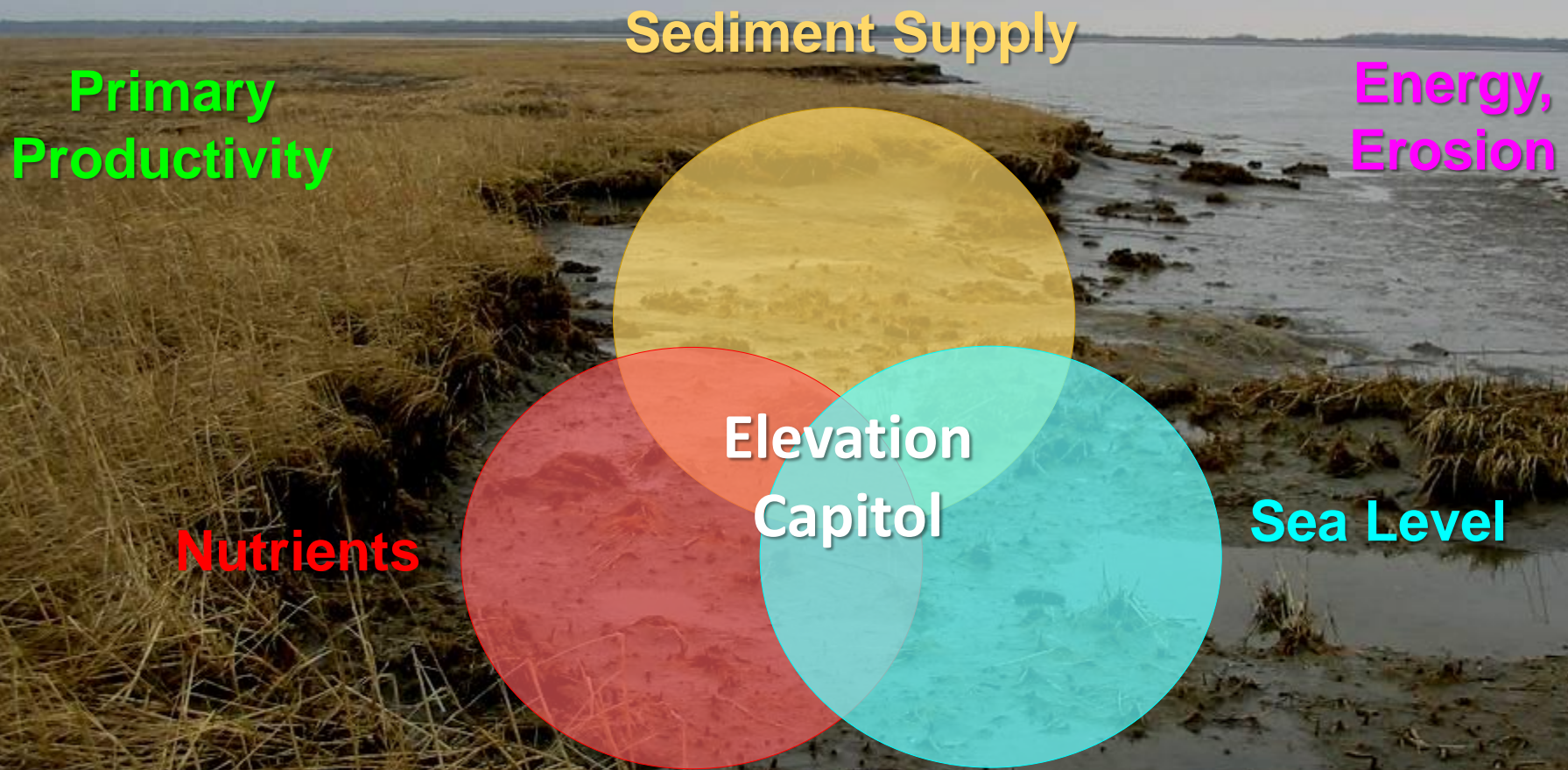


Unhappy Plants on
Nearby
Living Shoreline

Will Tidal Wetlands Keep Pace with SLR?

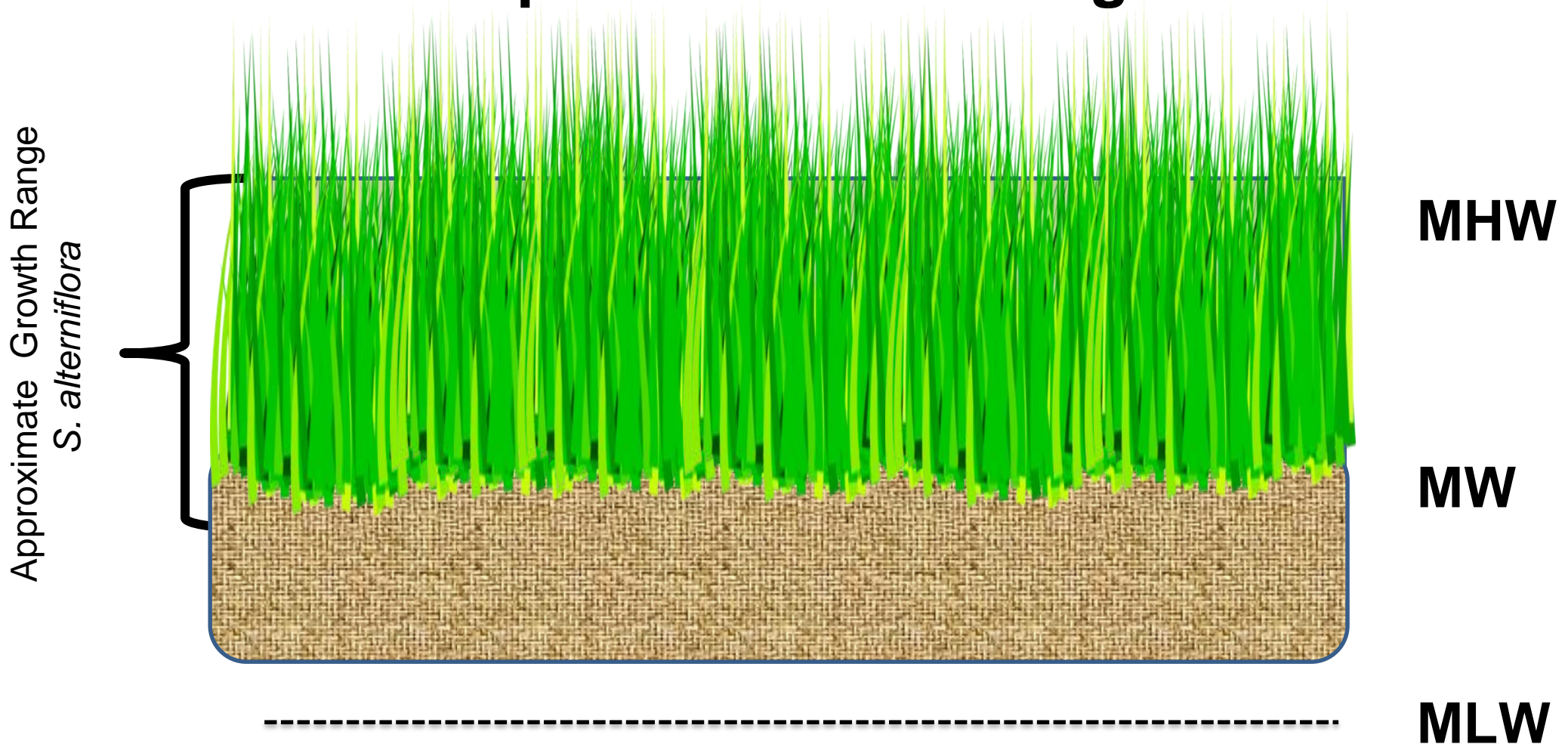


Will Tidal Wetlands Keep Pace with SLR?



Drowning (Vertical Loss)

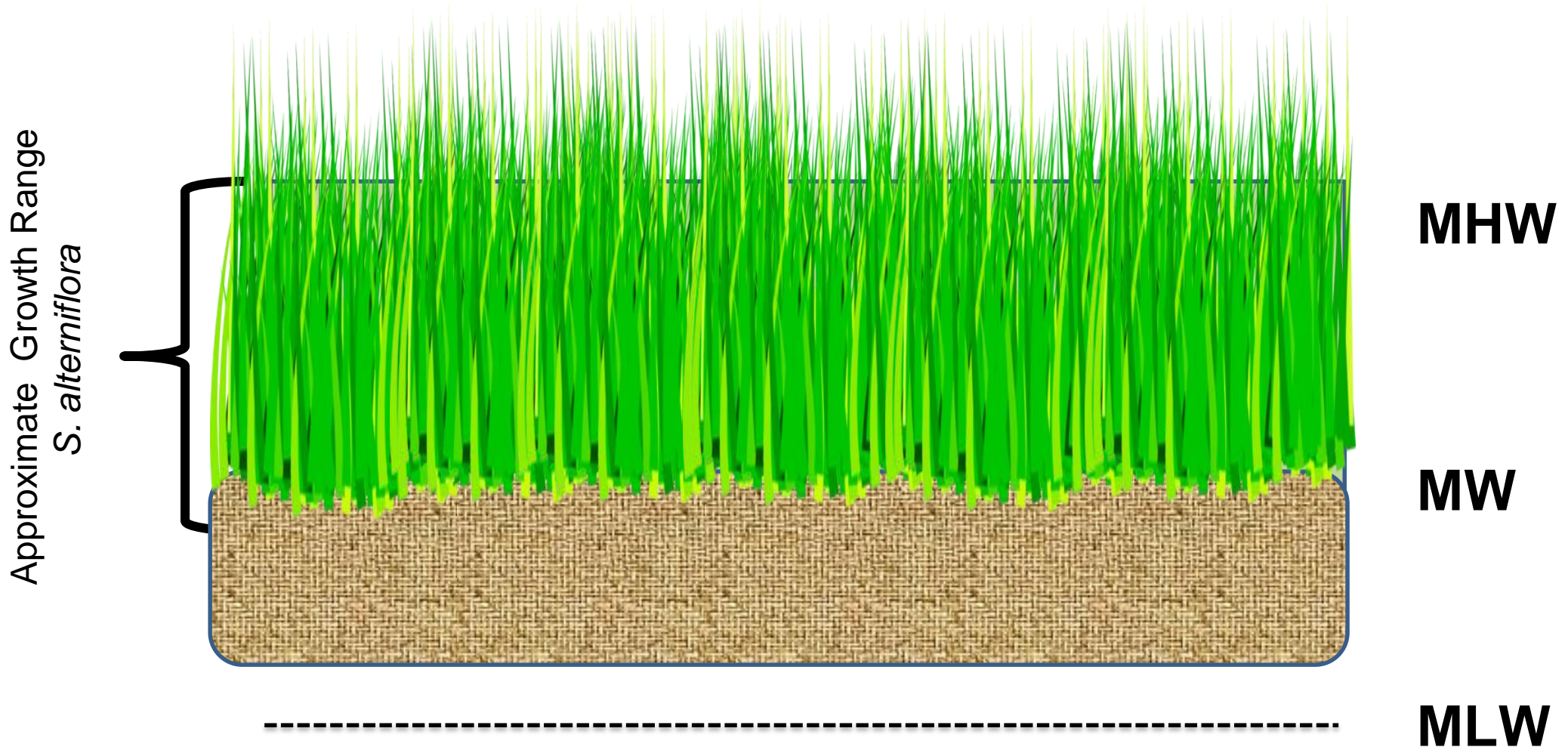
- Plants Have Optimal Growth Ranges



Slide adapted from James Morris

Drowning (Vertical Loss)

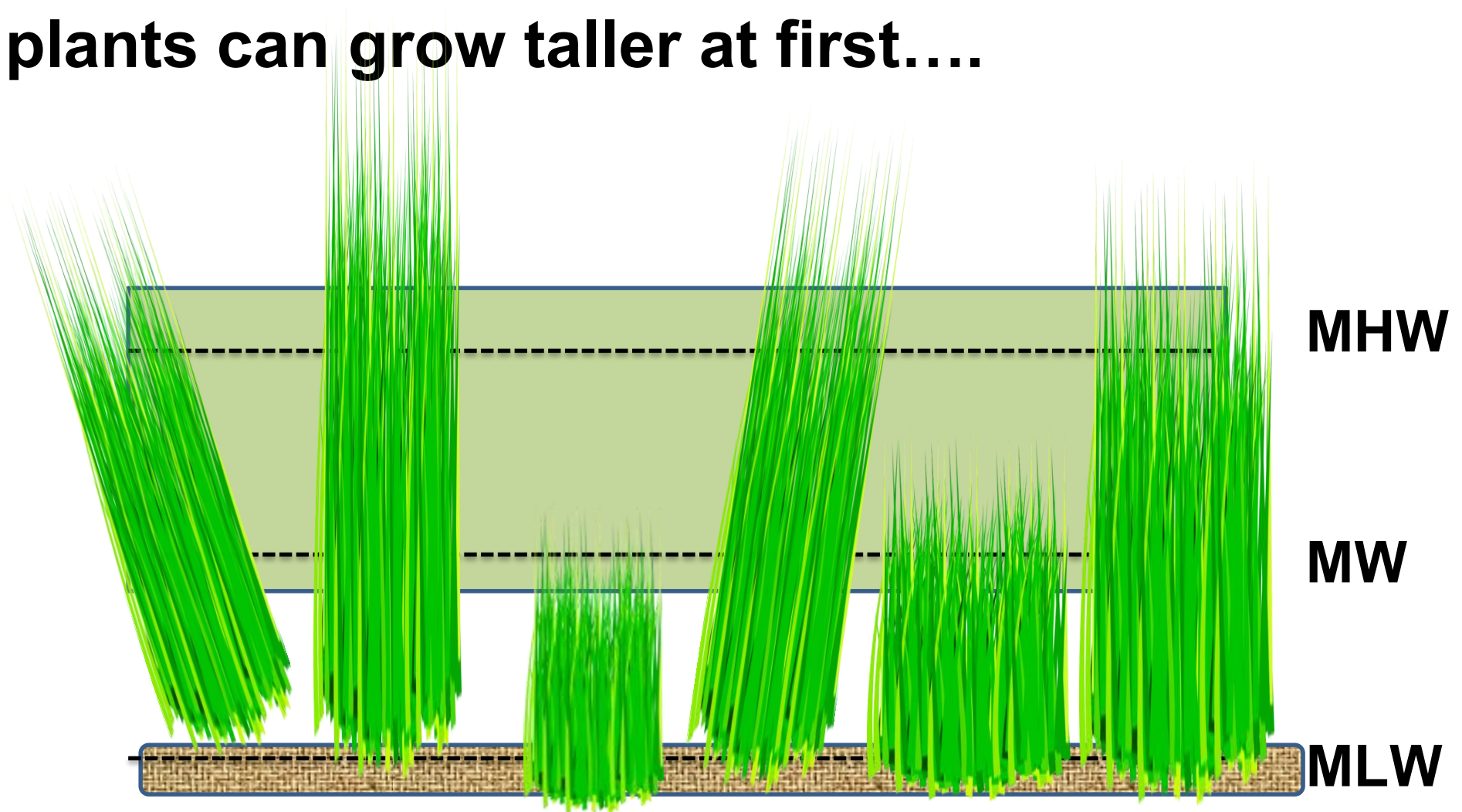
When rate of SLR $>$ rate of (net) accretion



Slide adapted from James Morris

Drowning (Vertical Loss)

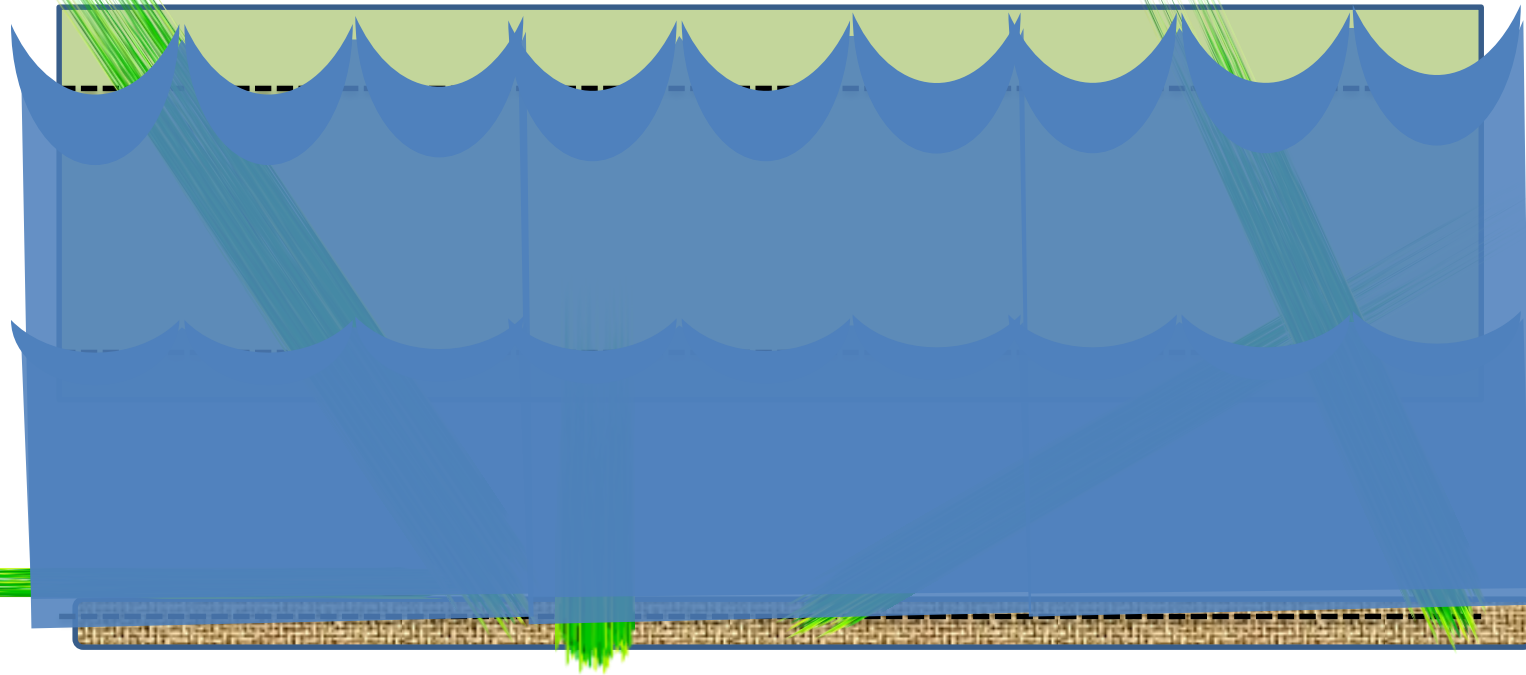
... plants can grow taller at first....



Slide adapted from James Morris

Drowning (Vertical Loss)

But eventually succumb

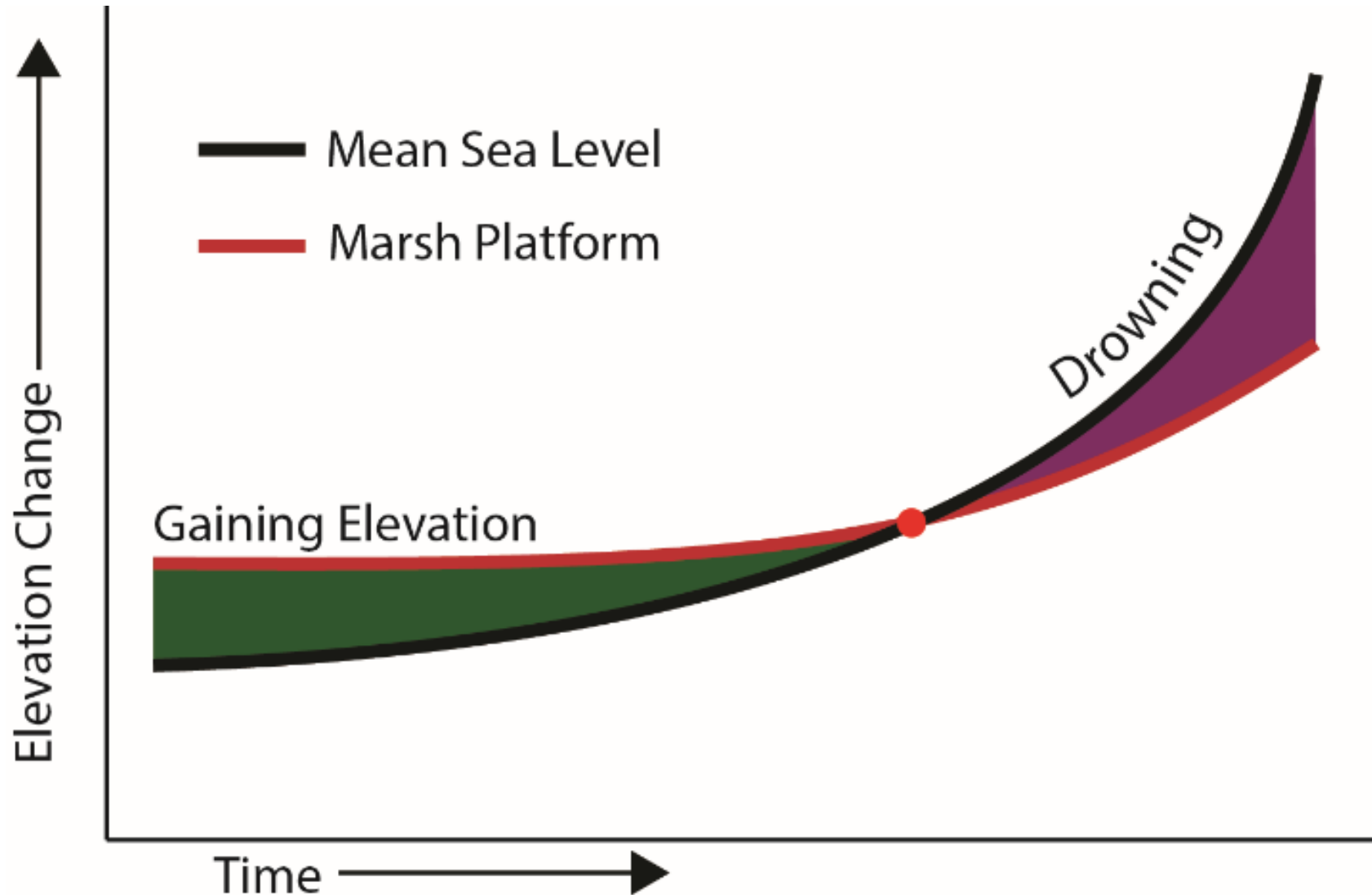


MHW

MW

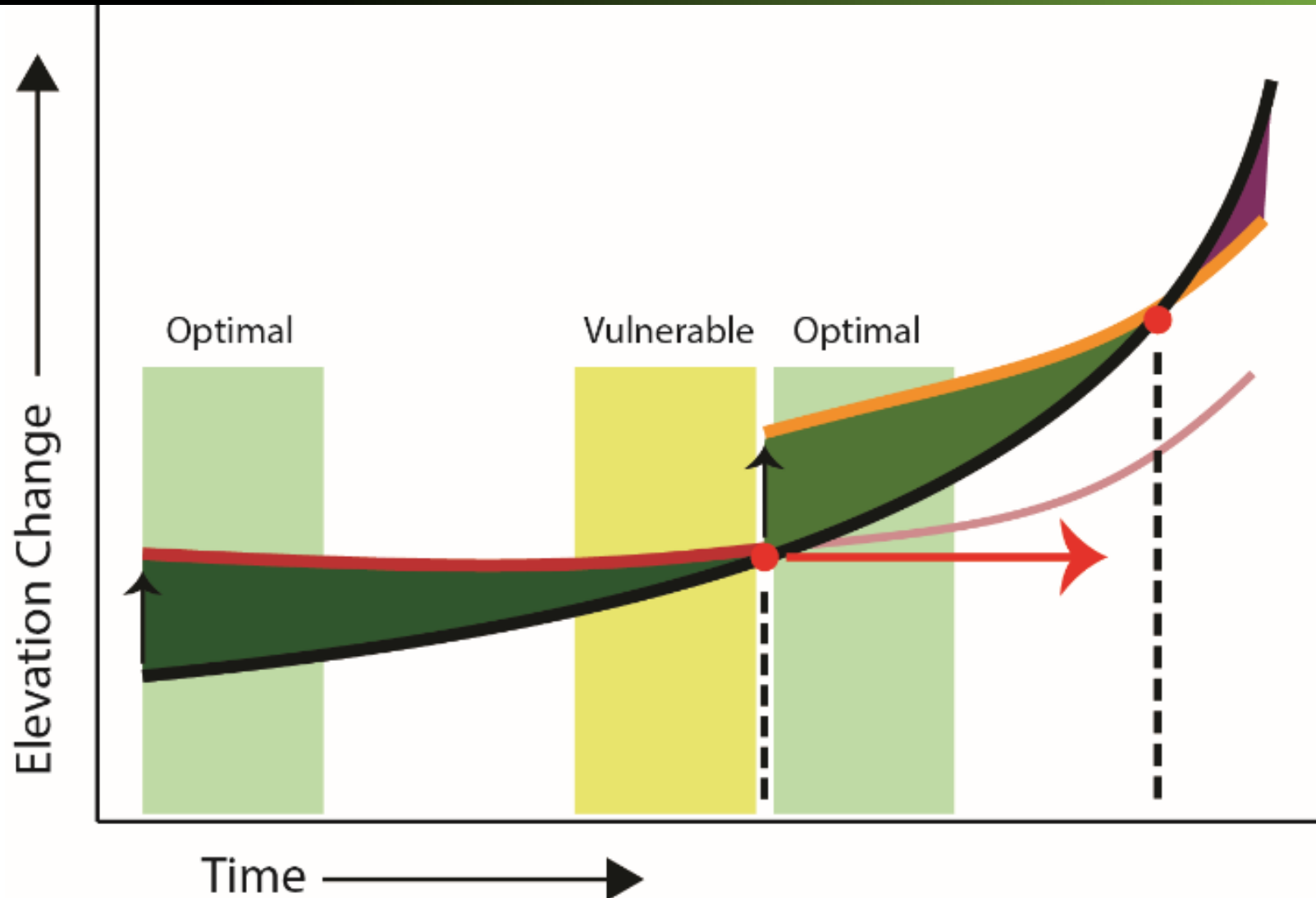
MLW

Elevation Capitol



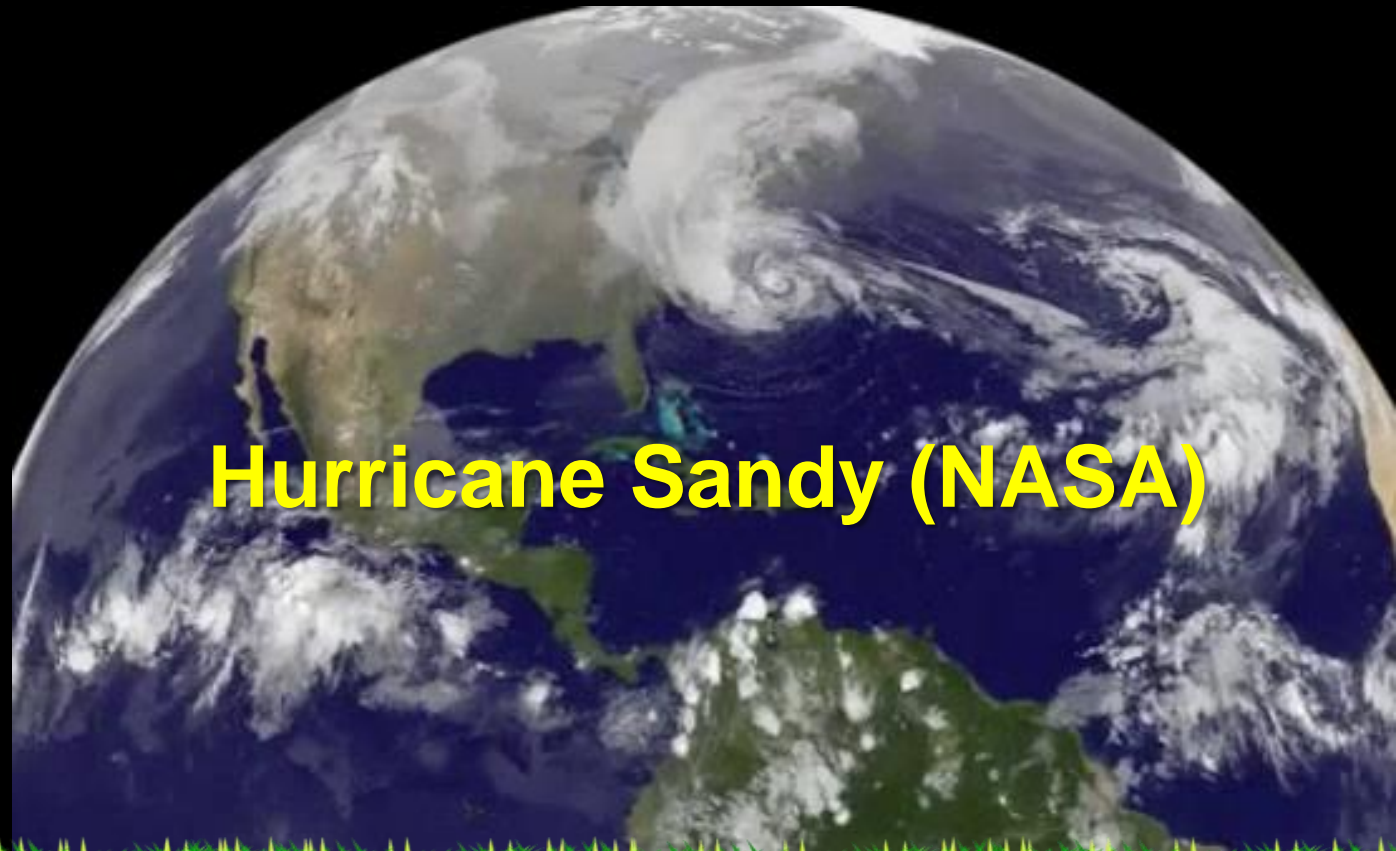
LeeAnn Haaf, PDE

Elevation Capitol

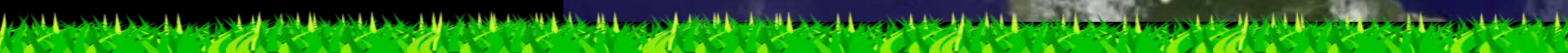


Coastal Resilience

→ Coastal Wetland Projects



Hurricane Sandy (NASA)





Post-Sandy Lessons

Flooding and storm damage was lower adjacent to protective coastal wetlands and dunes



Habitat Benefits

Aggregated Measure Type ¹	Category ²	Coastal Storm Risk Management Function		Erosion	Multi-Benefits ³	Resilience
		Flooding	Wave Attenuation			Adaptive Capacity ⁴
		Enhanced flood warning and evacuation planning (early)				
Deployable floodwalls	STR	Medium	None	None	None	Low
Floodwalls and levees	STR	High	Low	None	Low	Low
Shoreline stabilization (seawalls, revetments, bulkheads)	STR	Low	High	High	Low	Low
		Storm surge barriers		none	high	medium
Living shorelines	STR/NNBF	Low	Medium	Medium	High	High
Overwash fans (e.g., back bay tidal flats/fans)	NNBF	Low	Medium	High	Medium	High
Reefs	NNBF	Low	Medium	Medium	High	High
Submerged aquatic vegetation	NNBF	Low	Low	Low	High	Medium
Wetlands	NNBF	Low	Medium	Medium	High	High

Enhancement Tactics



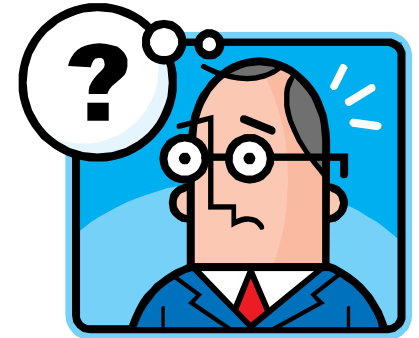
Oyster/Rock Breakwaters



Living Shorelines

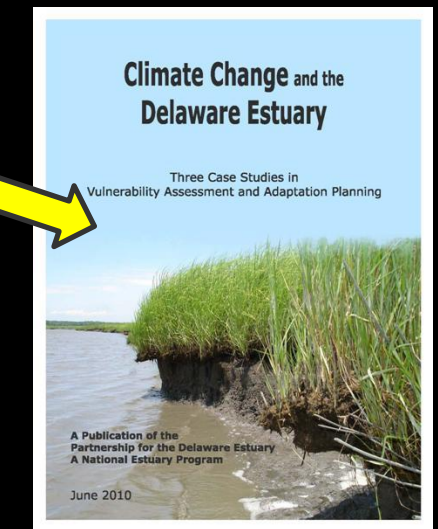
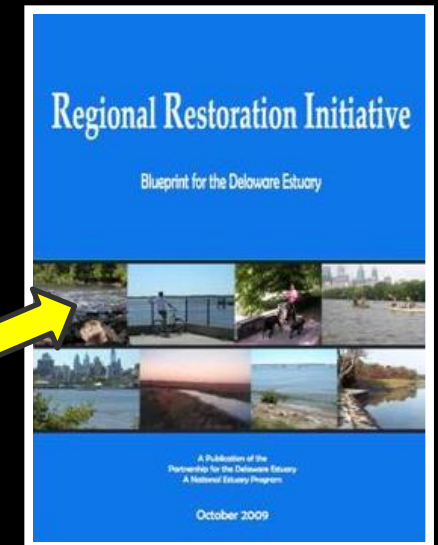
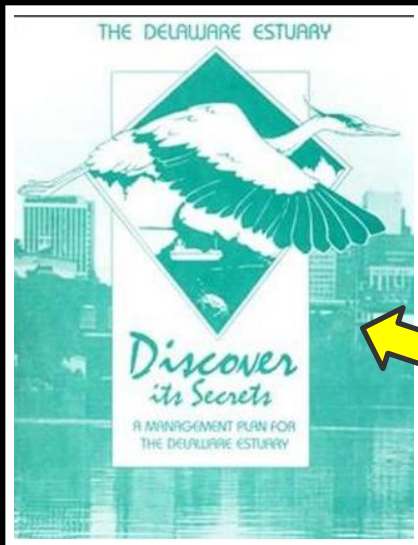


Sediment Placement



**What Tactics?
Where Best?
Successful?**

Sediments are a Critical Feature of the Delaware Estuary



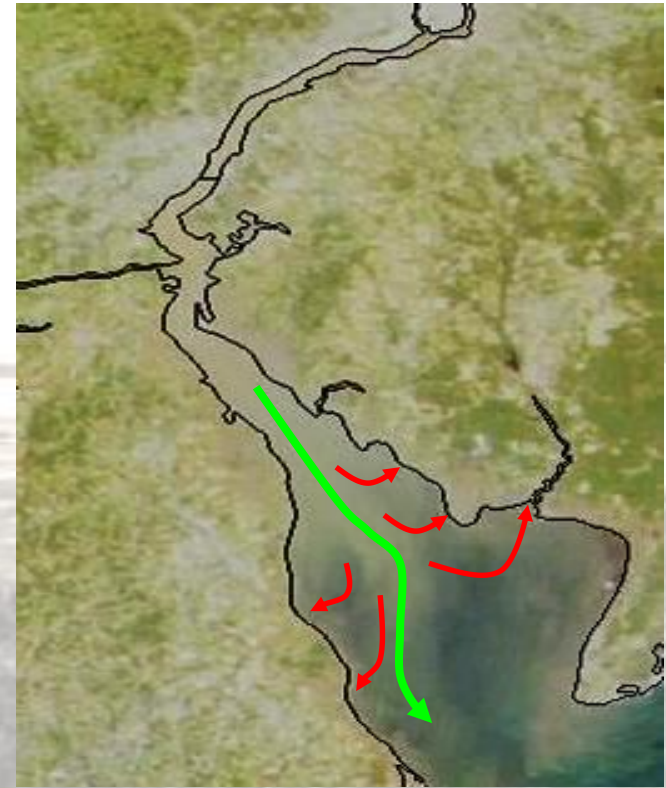
Beneficial Use

Why Needed?

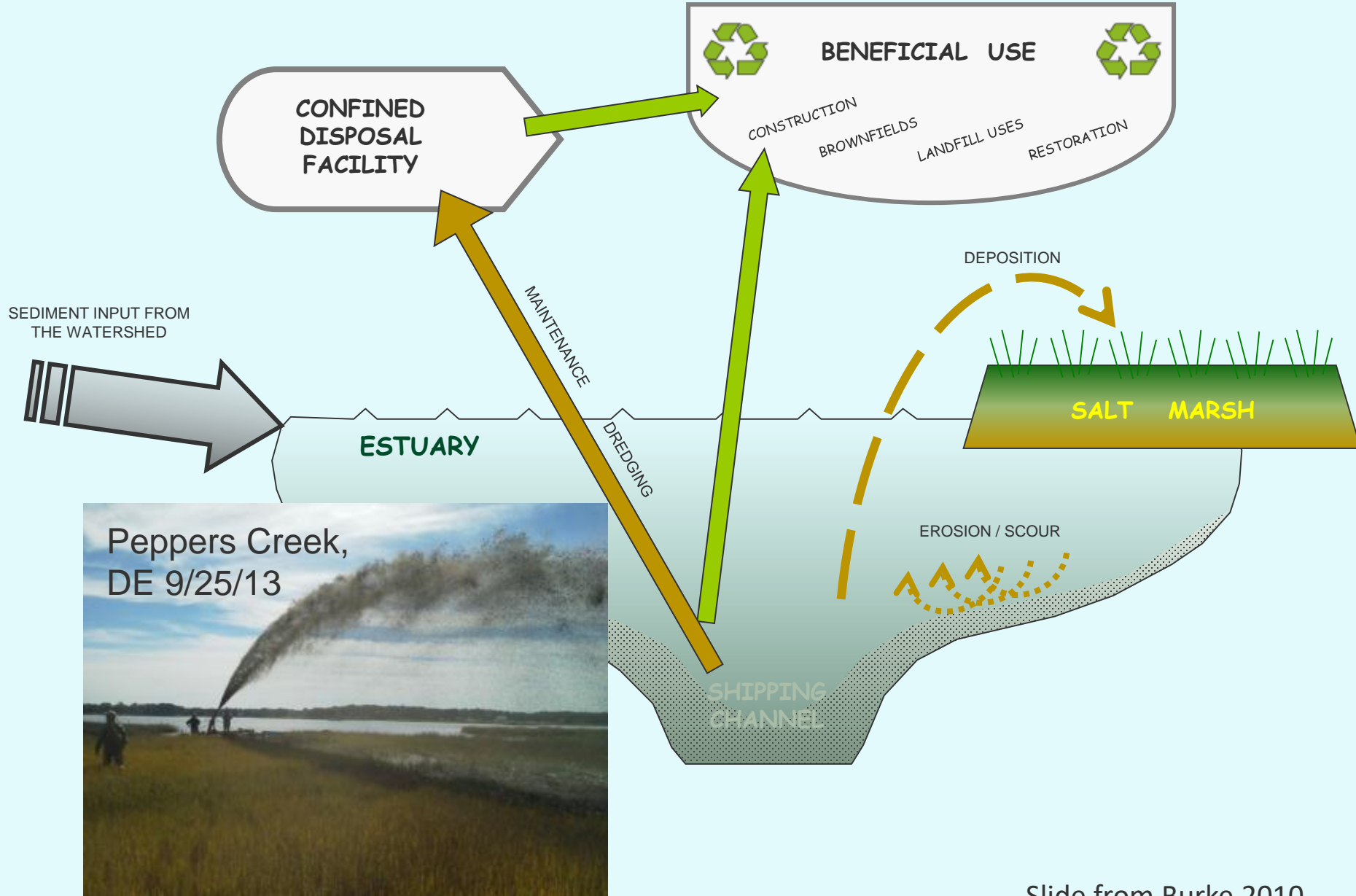
Marshes need sediments

More sediment is removed from the system by dredging than is replaced via river inputs

Sediment deficits can lead to marsh drowning



Restoration and Beneficial Use



Investment in Delaware Valley Lags

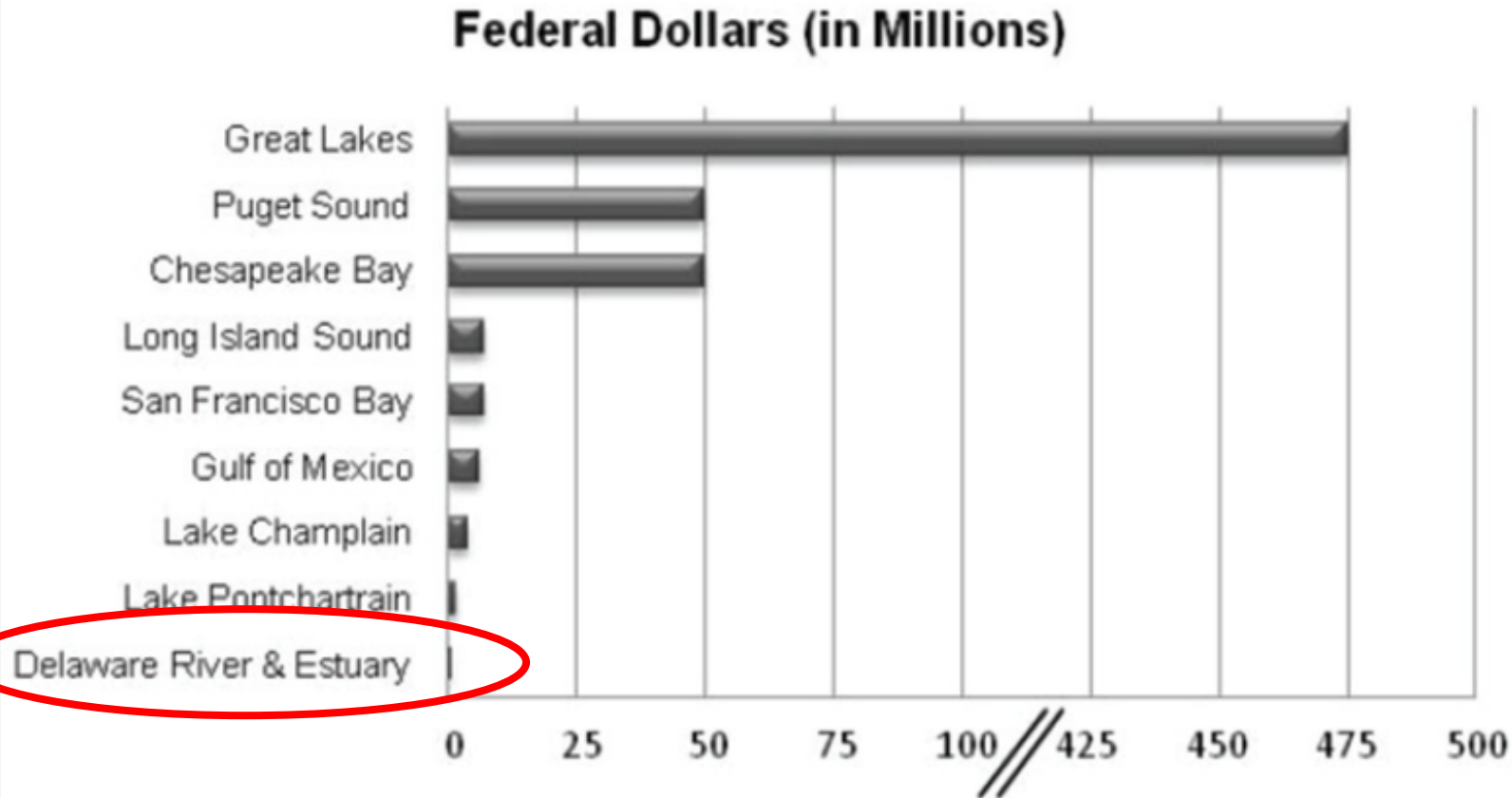
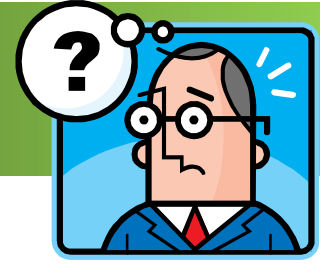


Fig. 8.8. Comparison of US EPA federal spending in FY2010 on environmental management and restoration in nine major water bodies in the United States (from Strackbein and Dawson 2011)

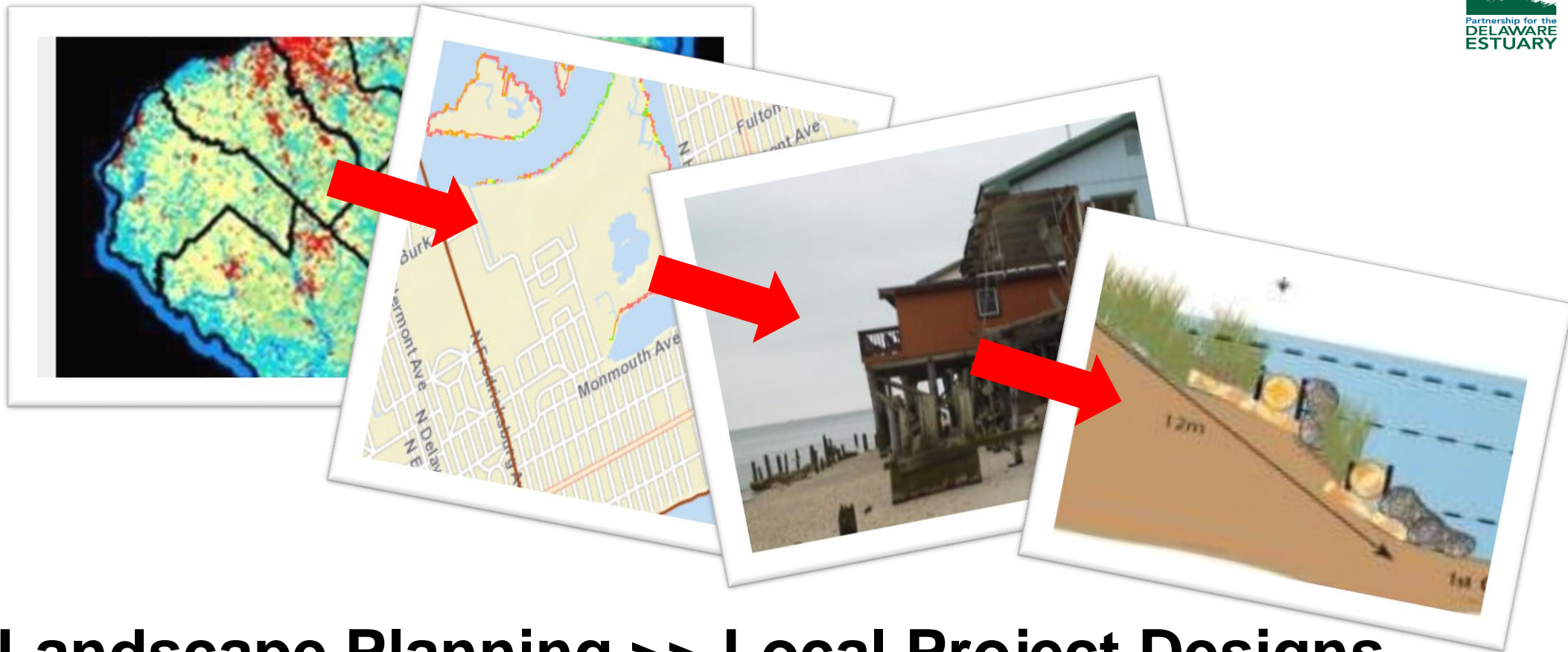
Despite Tough Times,...

High Potential
for Beneficial
Outcomes
from Natural
Infrastructure
Investment

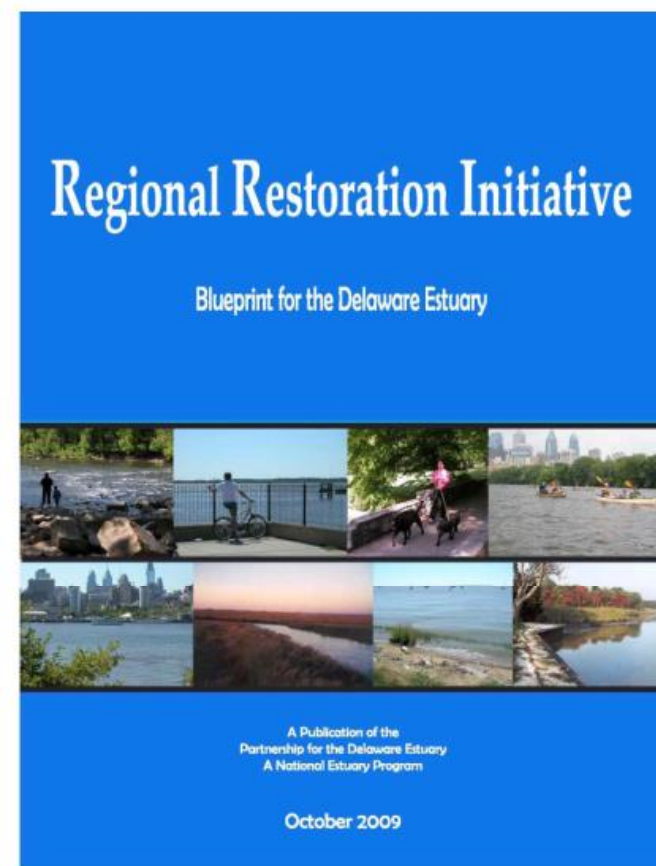
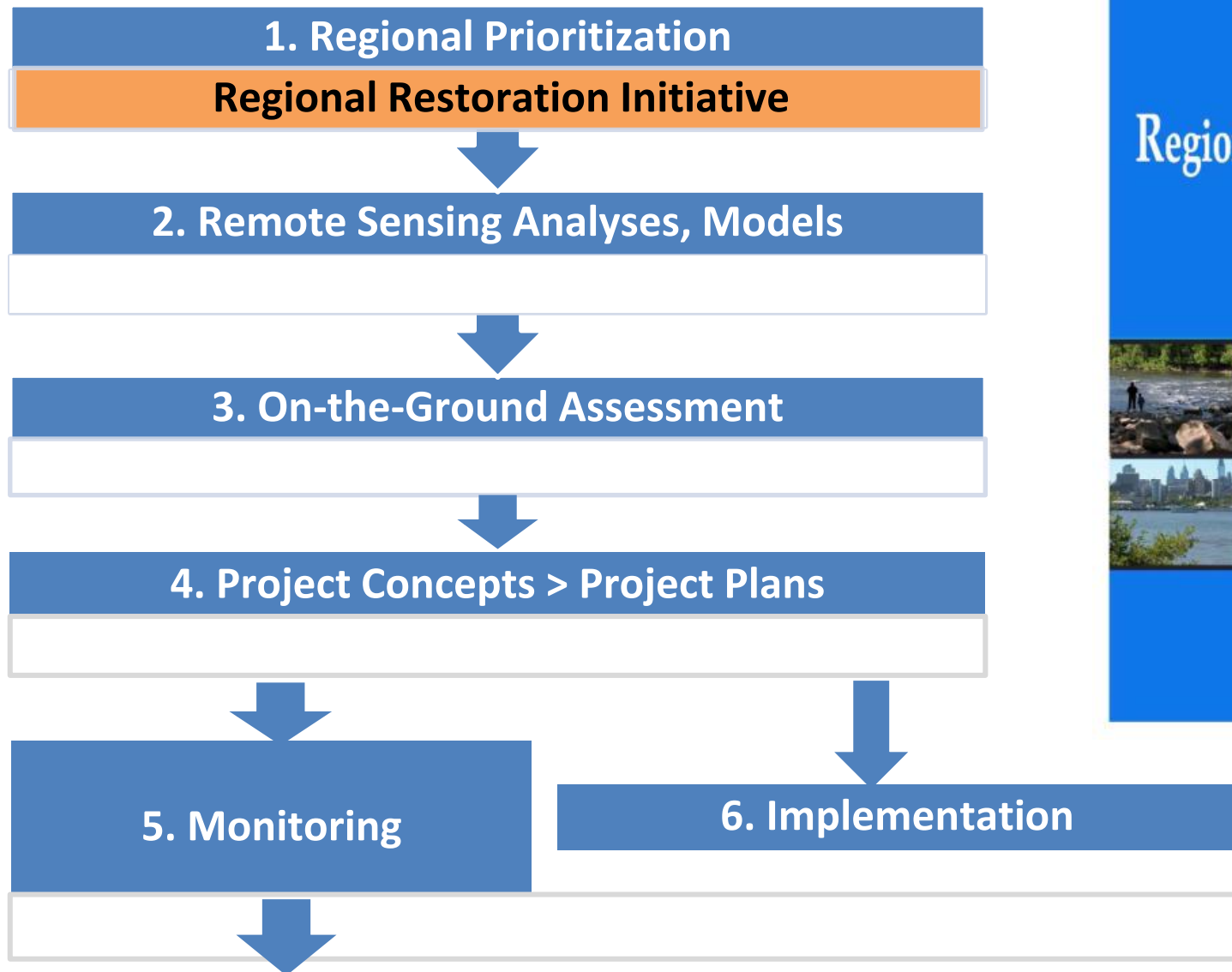
Deciding What to Do Where



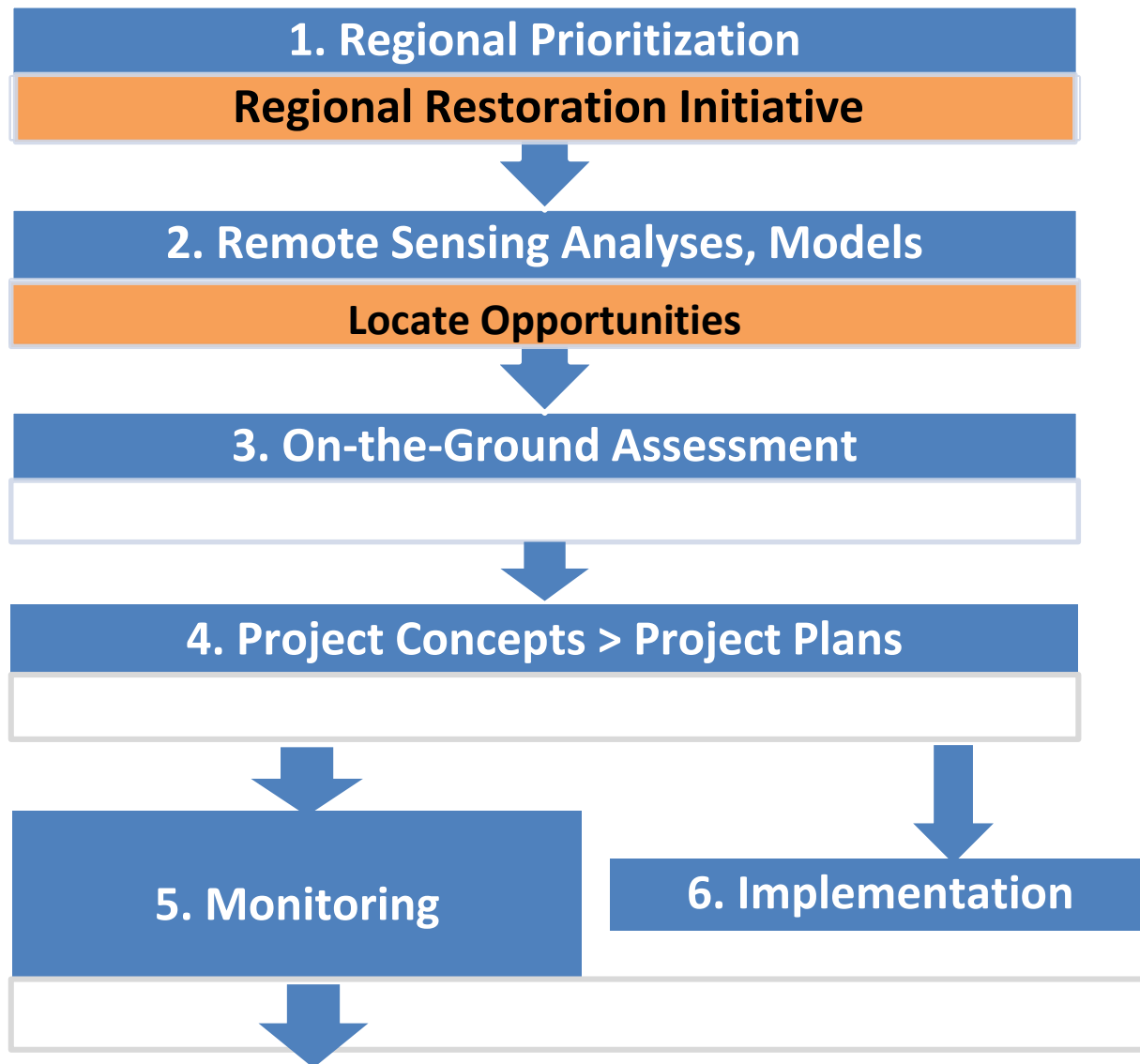
Hierarchical Analysis



Planning - Hierarchical Analysis



Planning - Hierarchical Analysis



Dredging Layer



Eco Needs Layer

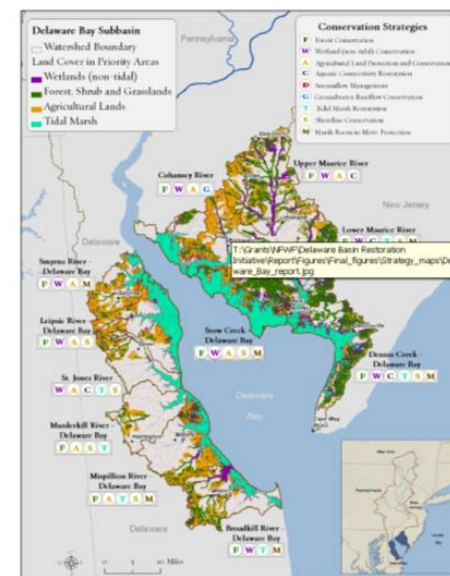


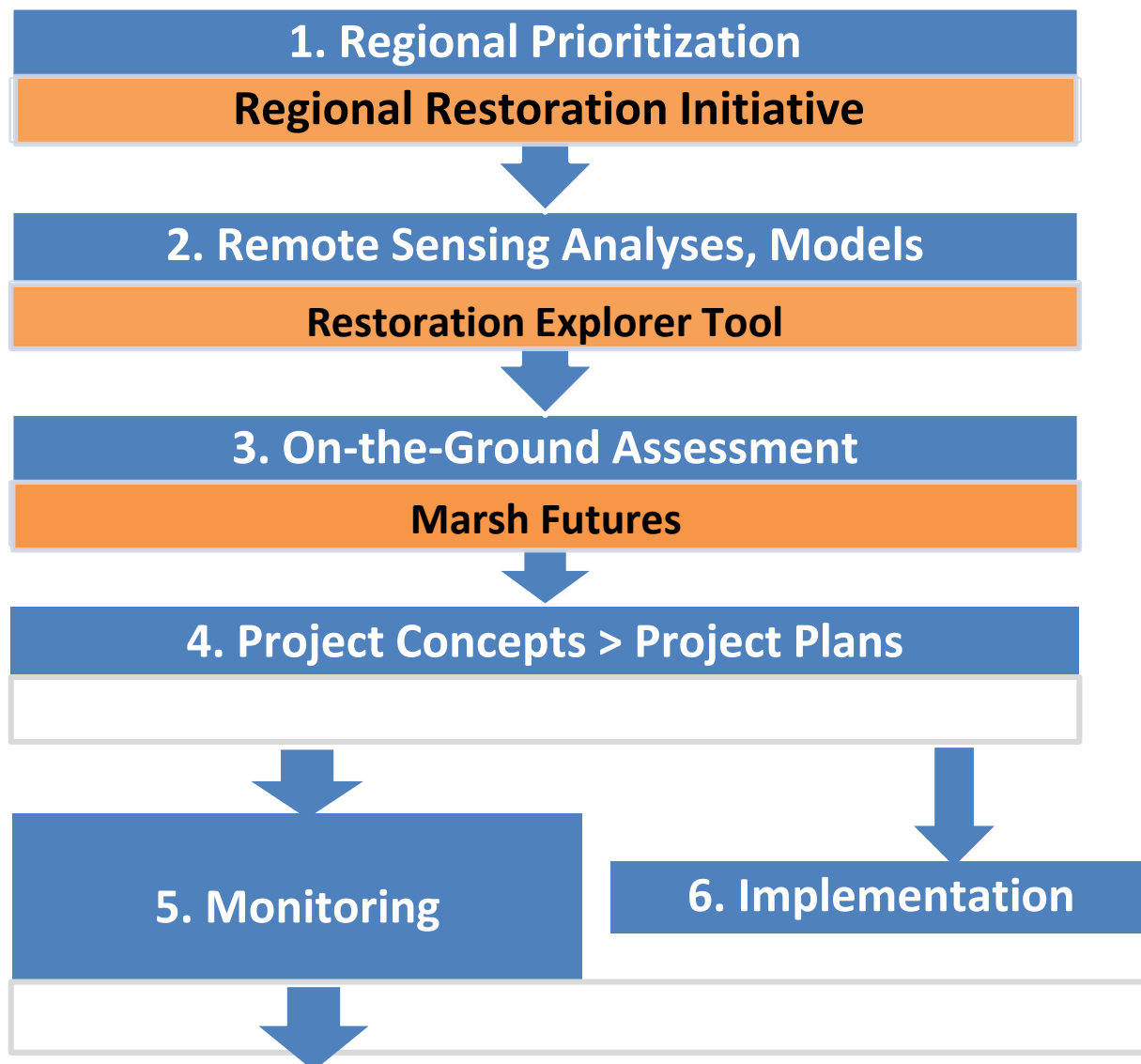
Figure 5.26. Priority conservation areas and recommended conservation strategies for the Delaware Bay sub-basin.

How to Judge Marsh Impairment?

Observations

- Wetland impairment can stem from diverse causes
- Pools, pannes, and short vegetation occur in healthy marshes
- Deficits in Elevation Capital (vertical vulnerability) are not always caused by lack of sediments
- Sediment application (TL) can help or harm a marsh
- Sediment impairment and TL opportunities should be identified with care using ecological reference datasets

Planning - Hierarchical Analysis



Marsh Futures Site Assessment

Goal: Develop a field-based rapid assessment method to guide suitable projects that enhance salt marsh integrity

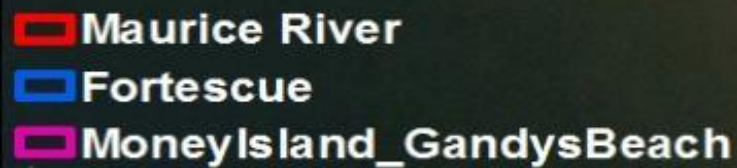
Outcomes:

- Vulnerability Maps
 - reflect horizontal/vertical processes
- Project Guidance Maps
 - reflect temporal/spatial needs

**Local Site
Planning**

**Verified
Conditions**

Partnership for the
**DELAWARE
ESTUARY**

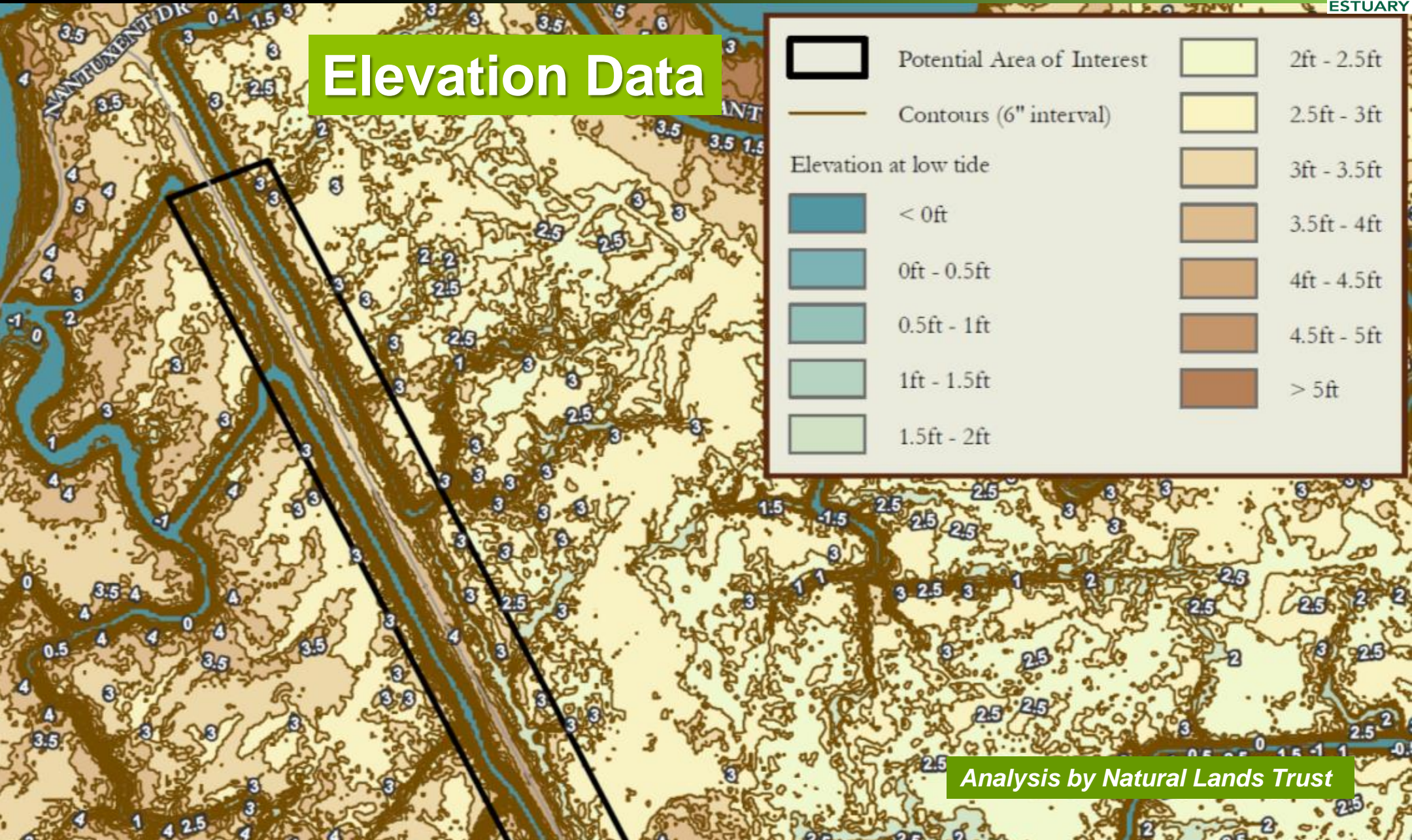


BaySIPP Areas of Interest

Source: Esri, DigitalGlobe, GeoEye, Earthstar, USDA, U.S.G.S, AeroGRID, IGN, and the GIS User Community

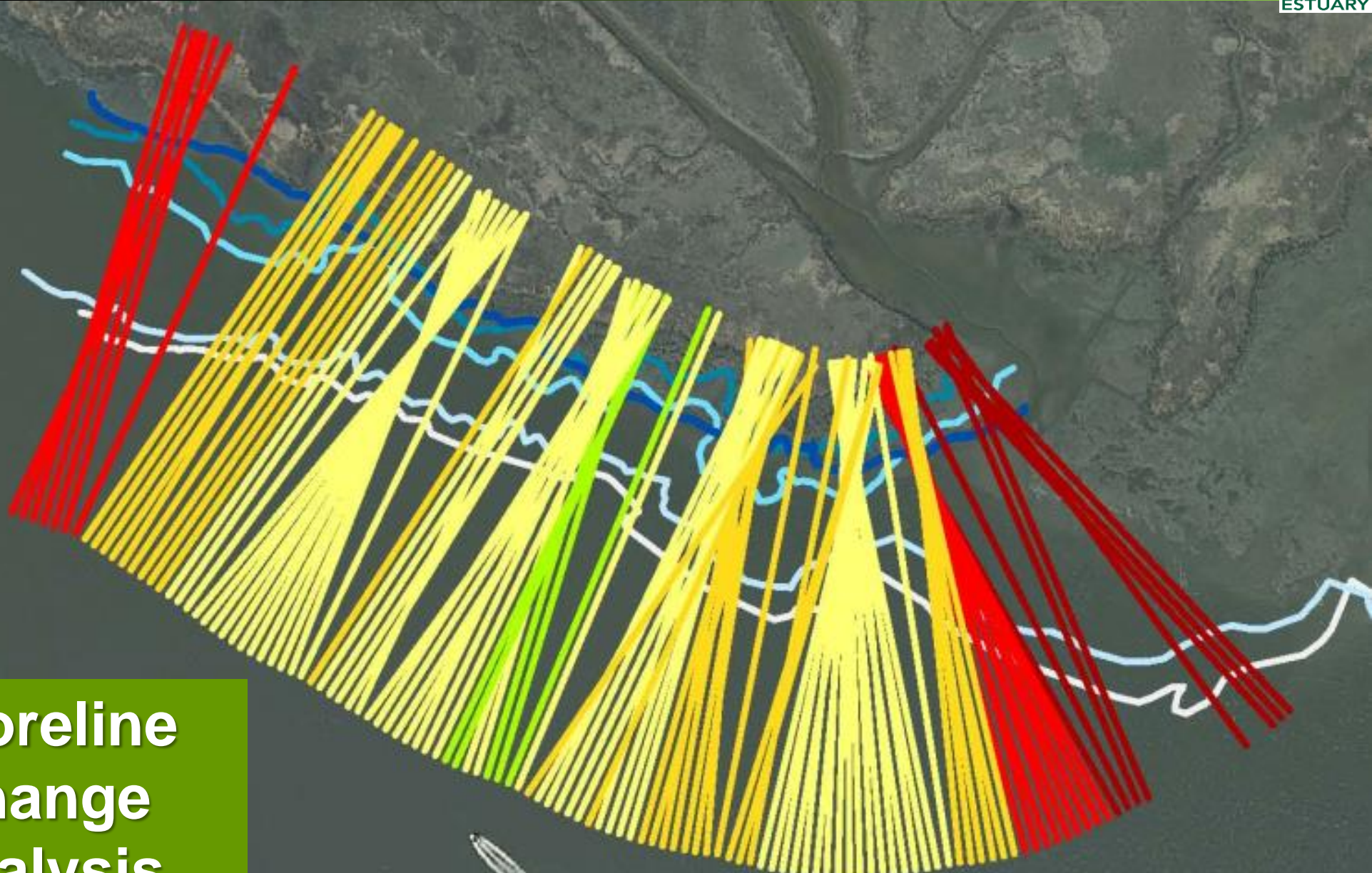
2. Desktop Analyses

Elevation Data



Analysis by Natural Lands Trust

2. Desktop Analyses



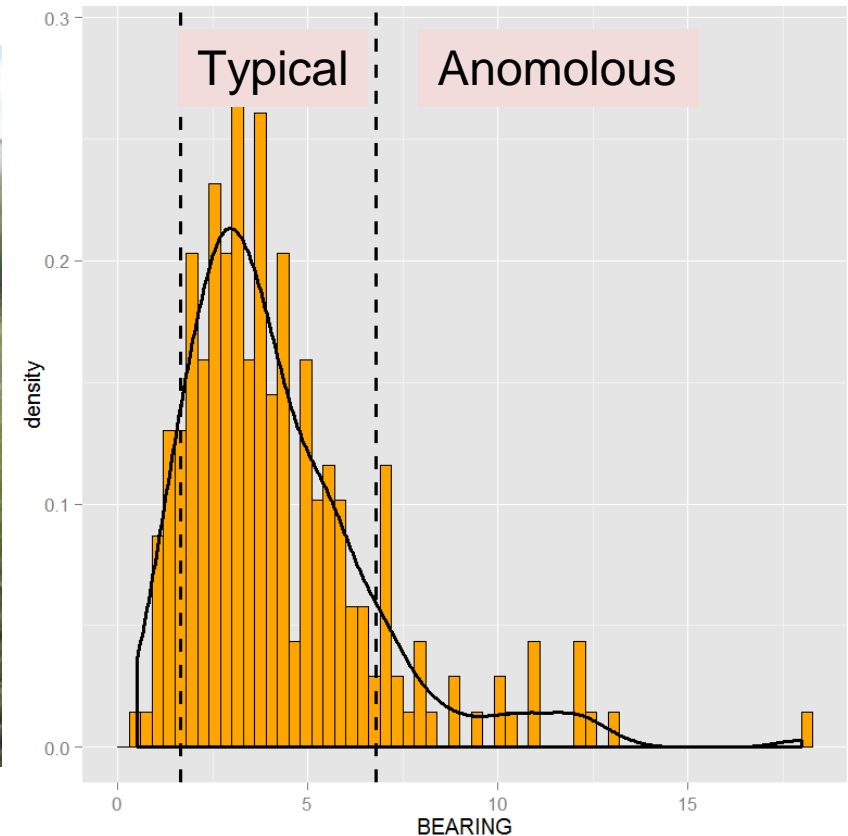
Shoreline
Change
Analysis

Natural Lands Trust Analysis using USGS Digital Shoreline Analysis System

3. Rapid Field Assessments

Physical – elevation, slope, erosion, substrate firmness

Biological – blade height, light penetration

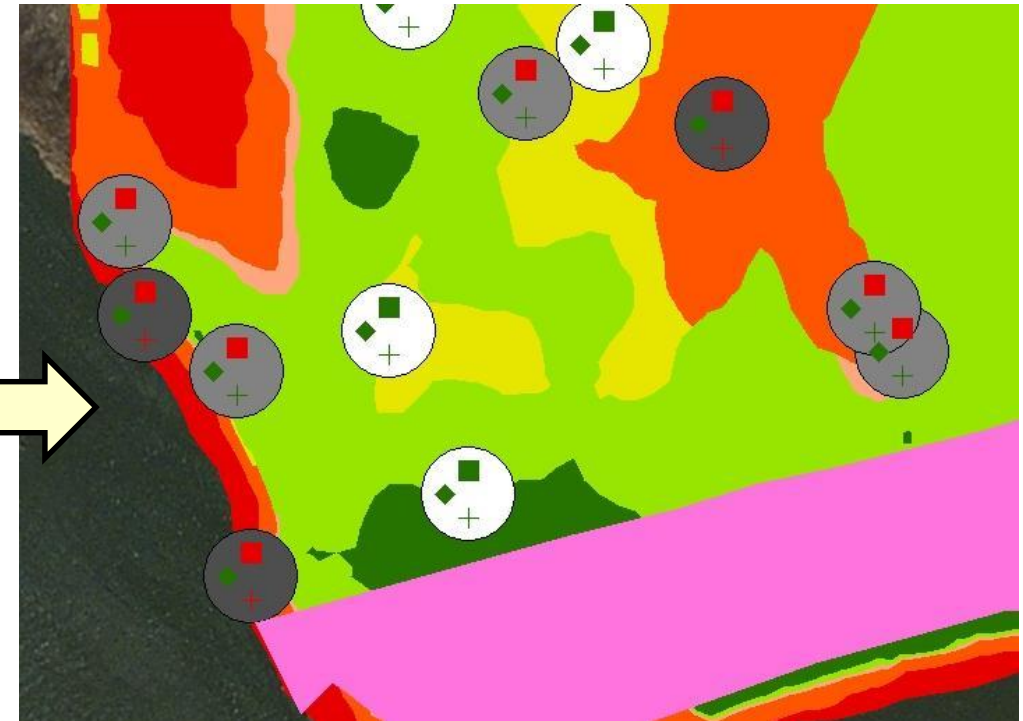


4. Vulnerability Mapping

Use anomalies as weights to
adjust elevation scores

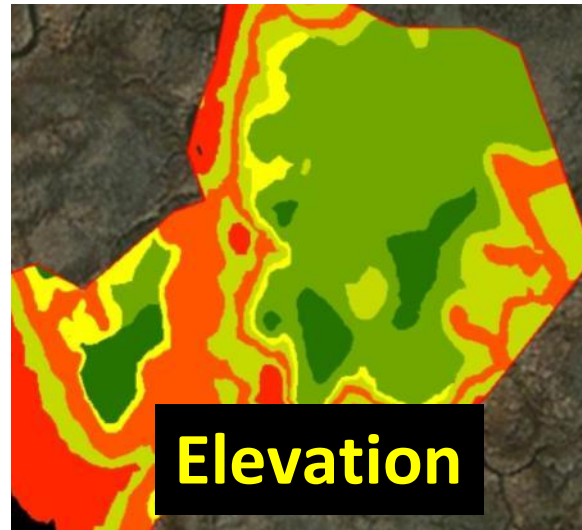
Elevation Capital Mapping

Weighted measures are unitless



4. Vulnerability Mapping

Drowning Risk



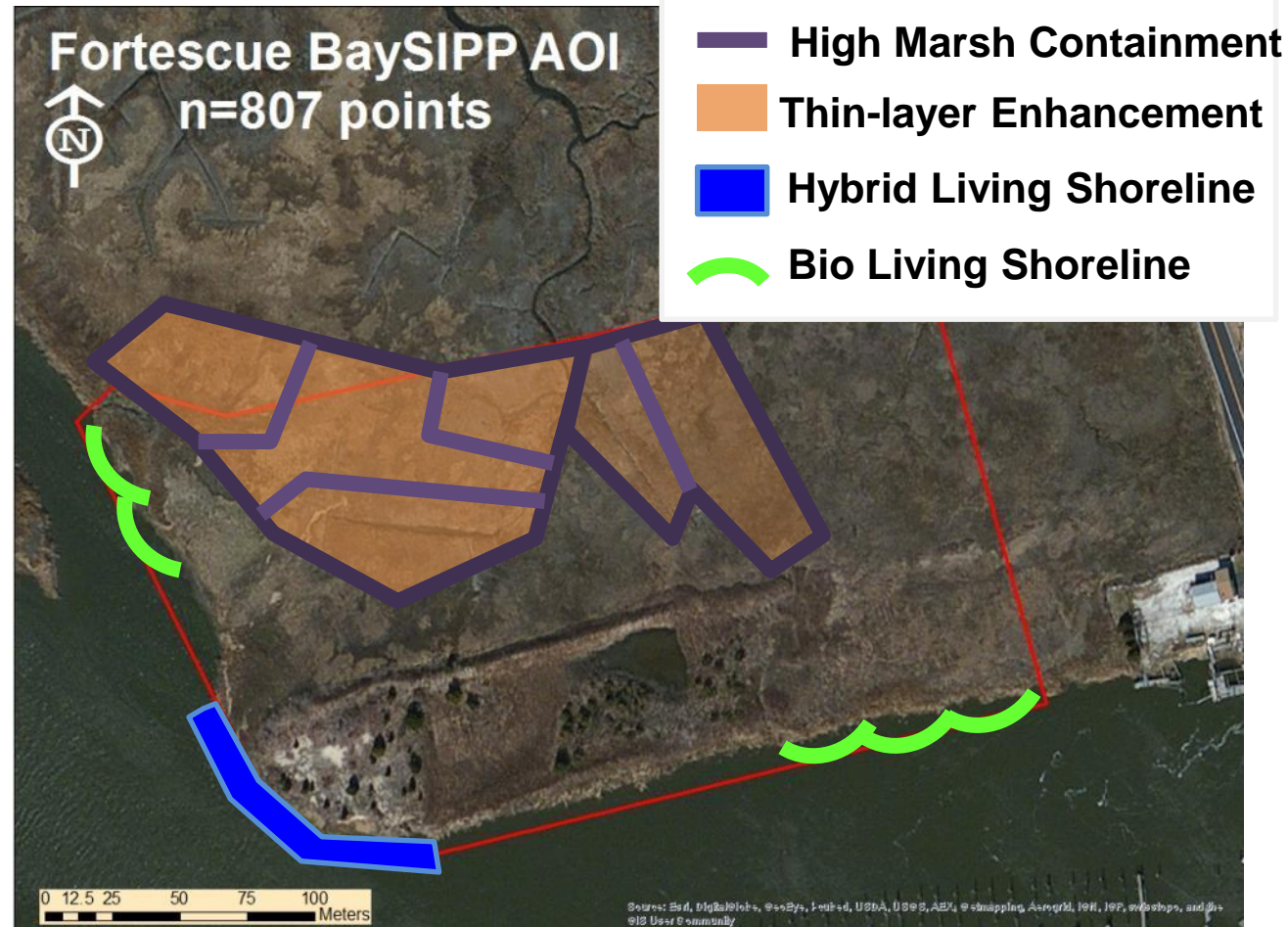
Erosion Risk



5. Project Guidance Mapping

Where will various investments yield greatest outcomes?

What should be the sequence of interventions?



Results – Vulnerability Maps

Edge Erosion Risk

Maurice >> Fortescue > Money Island

Interior Drowning Risk

Fortescue > Money Island > Maurice

Hydrological Impairment

Money Island > Fortescue > Maurice

Results – BMP Maps

Maurice:

Living Shorelines (aggressive mix needed)

Fortescue

Thin Layer Sediment (in low spots)

High Marsh Containment

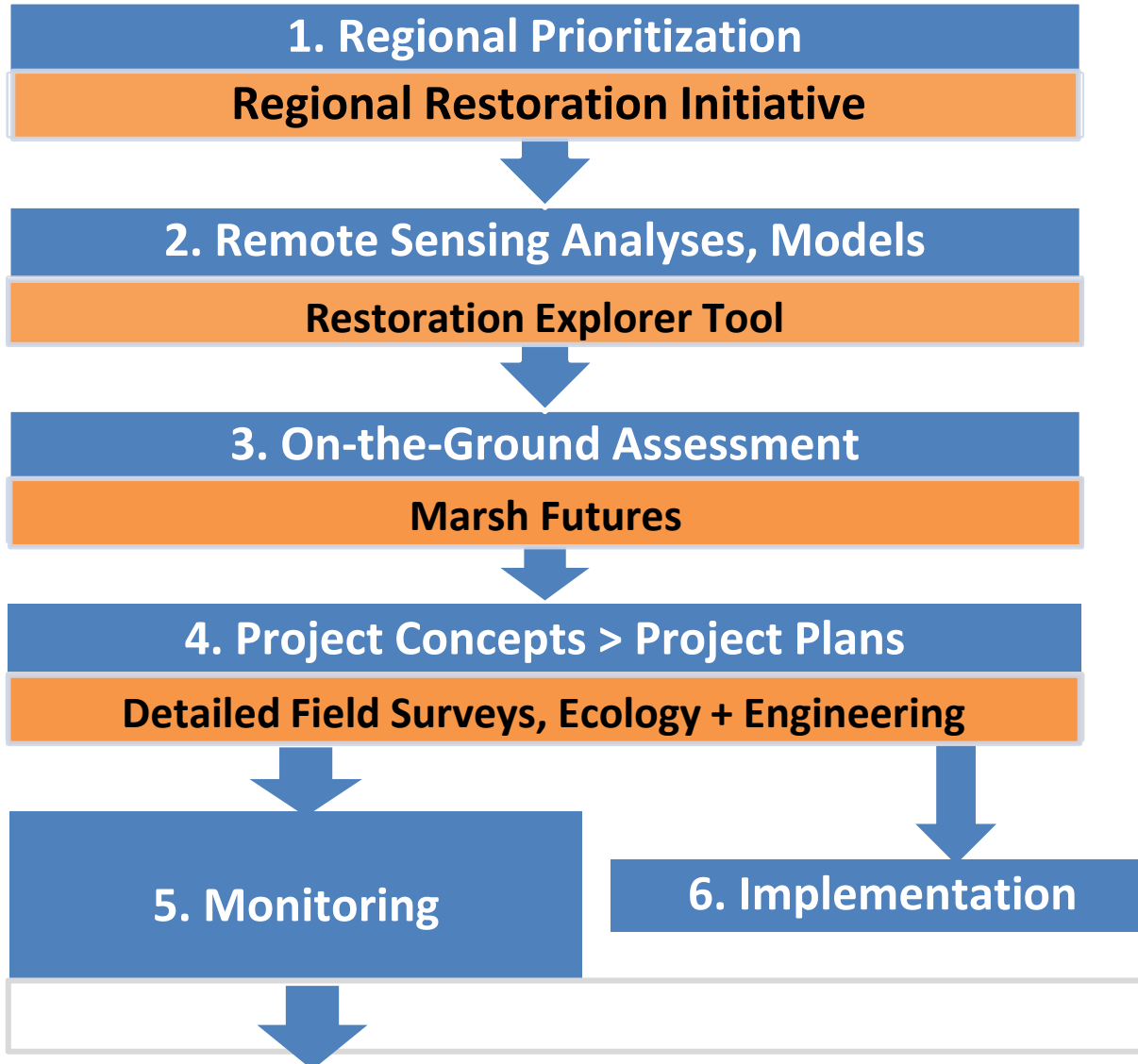
Living Shorelines (to maintain)

Money Island

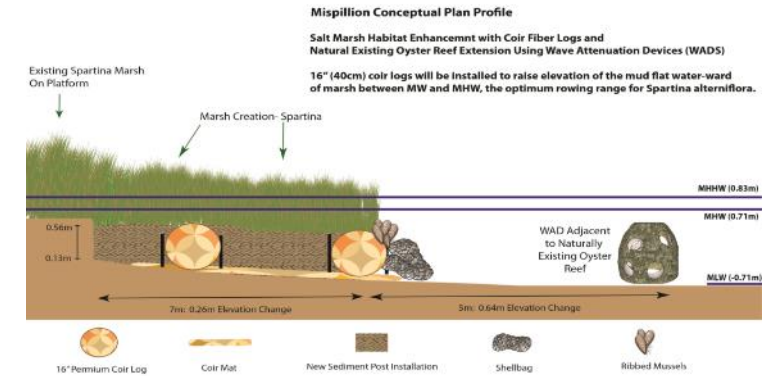
Hydrological Connectivity? (more study needed)

High Marsh Containment

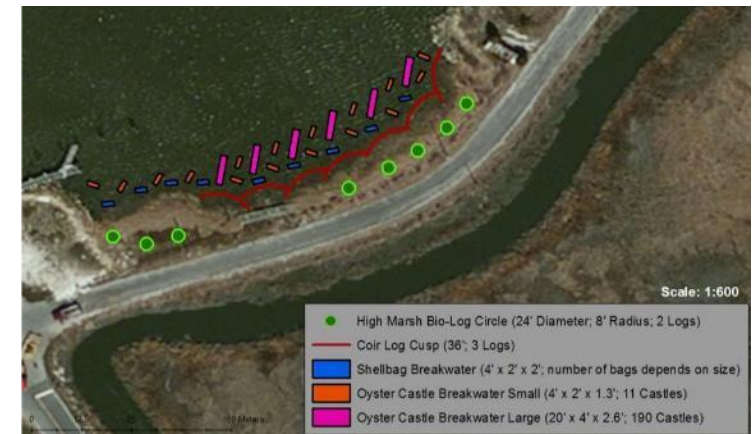
Planning - Hierarchical Analysis



Side View

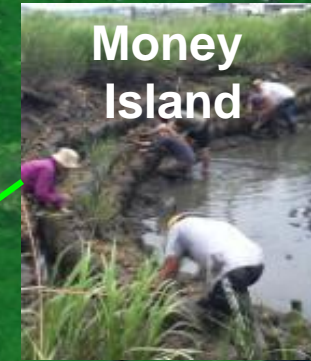


Top View



Delaware Estuary Living Shoreline Initiative

- Completed Projects
- Funded and Pending Projects
- Funded Projects
- Proposed Projects



United States Department of the Interior
U.S. Geological Survey

Recent Living shorelines



Money Island



Nantuxent Hybrid

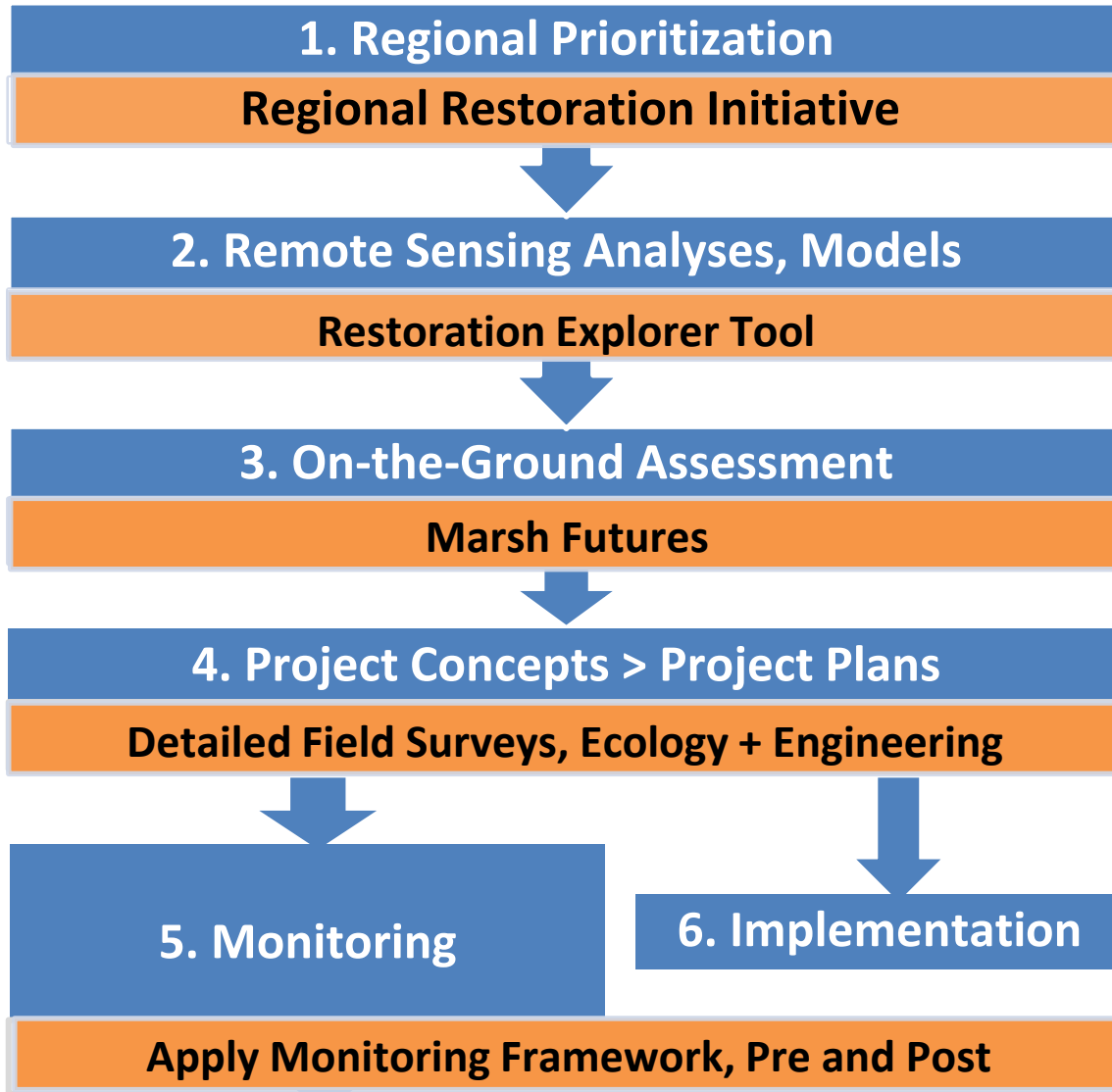


Lewes Canal



Mispillion Hybrid

Project Monitoring Linked to MACWA



Matts Landing, NJ

untreated area



treated area



Post Sandy
Bulkhead near LS

Maurice River, NJ

“Failed” living shoreline installed in 2008-2010



Living shoreline Monitoring Framework

Goal-based



Mispillion LS Monitoring

Core Metrics

Shellfish

Vegetation

Sedimentation

Structural Integrity

Metric Type	Attribute	Goal	Metric	Methods
Core	Physical	Shoreline Stabilization	Elevation Change	RTK
Core	Physical	Shoreline Stabilization	Contiguous Vegetated Edge	RTK
Core	Physical	Shoreline Stabilization	Sediment Capture	RTK
Supplemental	Physical	Shoreline Stabilization	Bearing Capacity	Slide Hammer
Supplemental	Physical	Shoreline Stabilization	Sediment Accretion	Feldspar Marker Horizon
Core	Biological	Ecological Enhancement	Vegetation Robustness	Vegetation Board
Core	Biological	Ecological Enhancement	Vegetation Integrity	Blade Height
Core	Biological	Ecological Enhancement	Extent of Bivalve Communities	Lip Counts Oyster Reef Extent
Core	Biological	Ecological Enhancement	Extent of Bivalve Communities	Shell Bag Recruitment
Core	Biological	Ecological Enhancement	Inhibition of "Critter" Movement	Presence/Absence of Trapped "Critters"
Core	Chemical	Prevailing Environmental Conditions	Temperature	YSI
Core	Chemical	Prevailing Environmental Conditions	Salinity	YSI
Core	Other	Structural Integrity of Materials	Coir Logs	Observation
Core	Other	Structural Integrity of Materials	Coir Mats	Observation
Core	Other	Structural Integrity of Materials	Shellbags	Observation
Core	Other	Structural Integrity of Materials	Hardened Structures	Observation
Core	Other	Disturbance	Anthropogenic	Observation
Core	Other	Disturbance	Wildlife	Observation
Core	Other	Photo Documentation		Camera

Statistical Approach = BACIR

Before – After - Control – Indicator - Reference

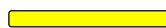
Marsh
Treatments



Oyster
Breakwater



Controls



Reference =
nearest
MACWA
station



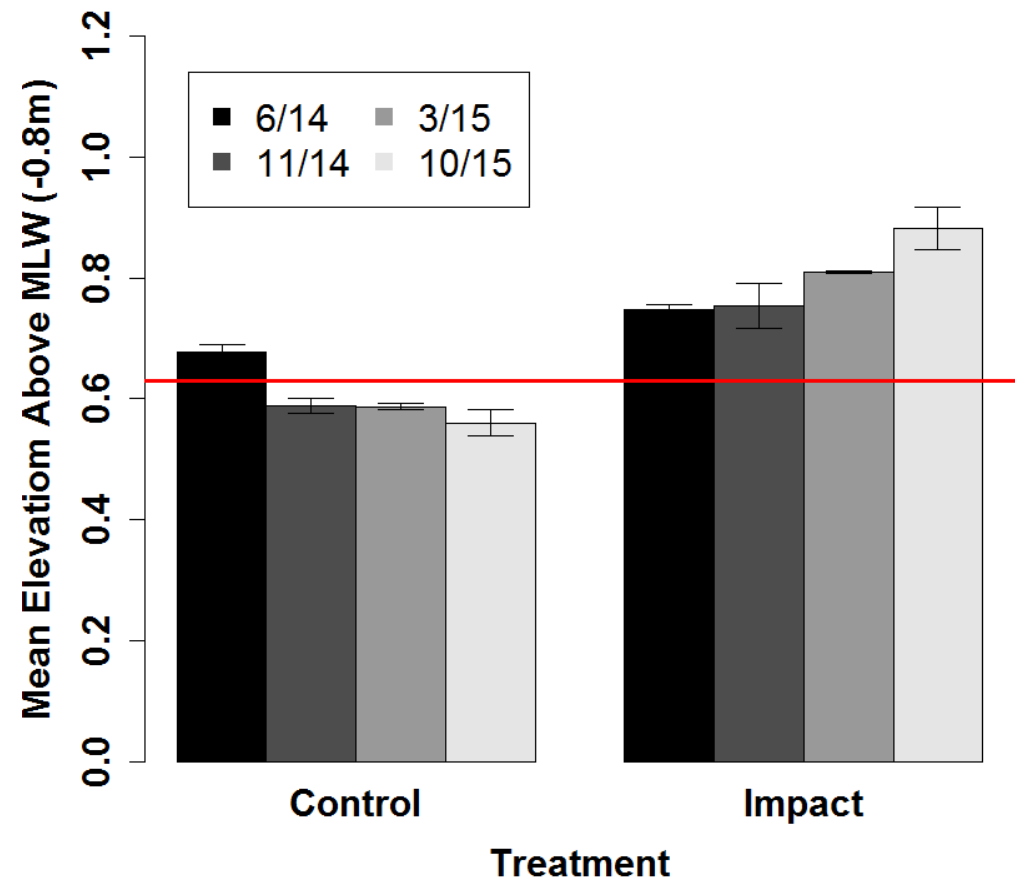
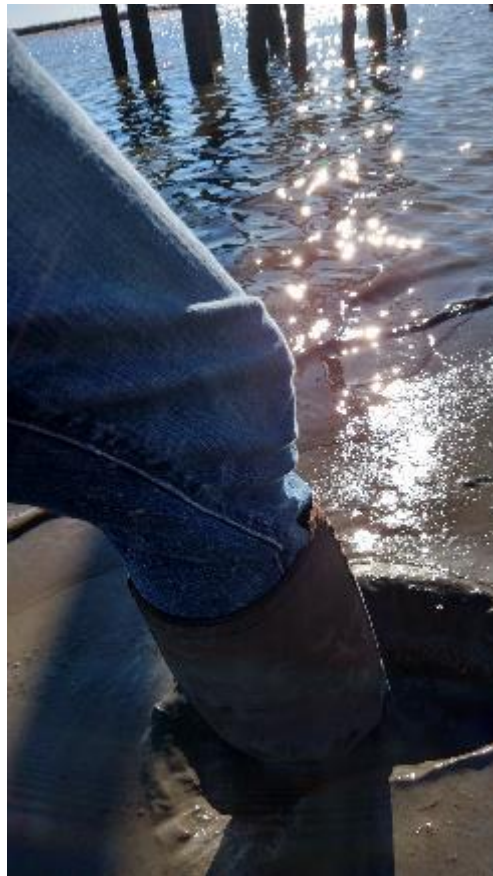
Mispillion LS Results - Physical

Did Sediment Collect?

Yes

Treated areas
gained elevation

Untreated areas
continued to lose
elevation



Mispillion LS Results - Biological

Did Plants Survive?

Yes



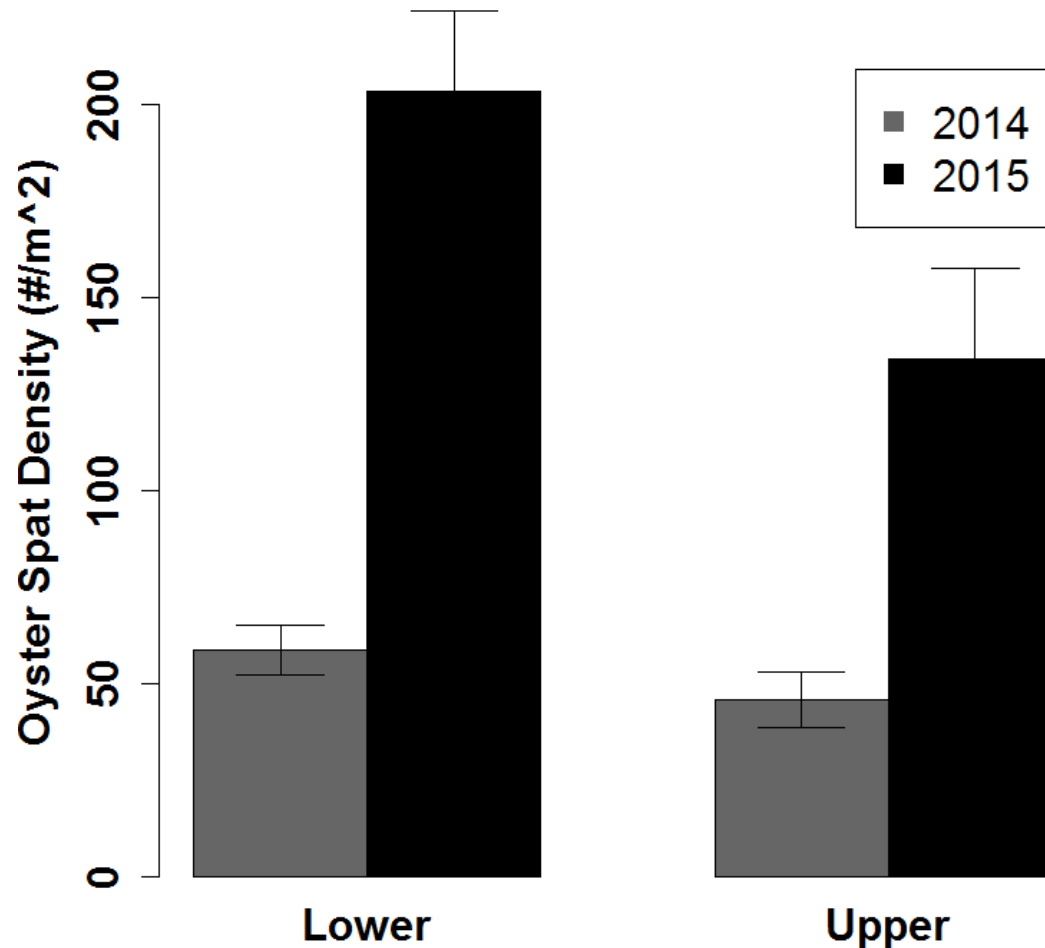
Mispillion LS Results - Biological

Did Shellfish Colonize Structures?

Yes

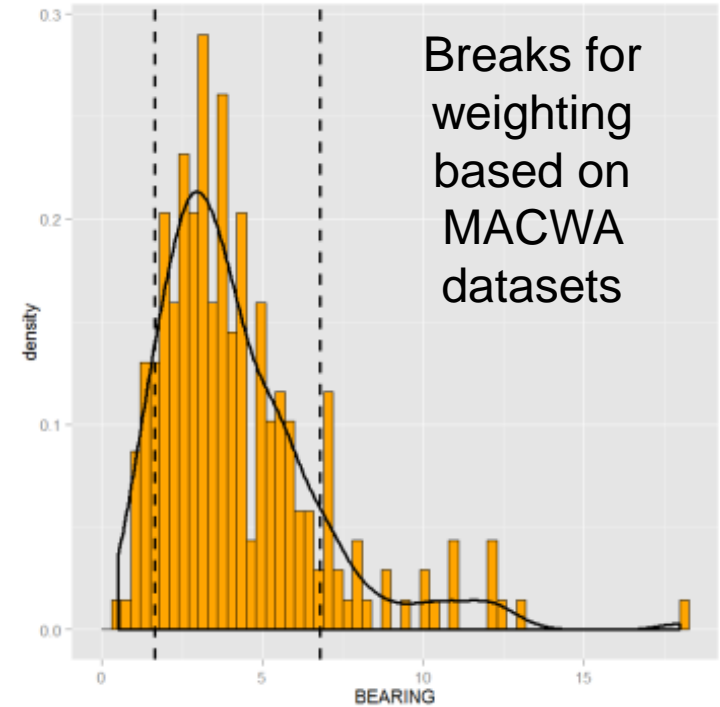
Good oyster
recruitment in 2014,
better in 2015

Mussel data still being
analyzed



Next Steps for Marsh Futures

- **Refine Metrics to reflect different types of vulnerabilities**
- **Streamline field efforts to more rapidly assess sites or expand to larger areas**



Conclusions

- Tidal wetlands are vital for coastal resilience in the Delaware Estuary region, but are in decline
- Well-designed restoration projects are needed and should address specific ecological impairments
- Marsh Futures is an example method for providing project guidance using ecological datasets
- Beneficial use of dredged sediments can help address certain types of marsh impairment if carefully deduced and matched to ecological needs; but there is risk of harm
- Most tidal wetland decline is due to edge erosion, and restoration of lost and degraded marsh edges may offer greater bang for buck compared to platform elevation



[For More Info](#)

PDE Report No. 15-03. Marsh Futures: use of scientific survey tools to assess local salt marsh vulnerability and chart best management practices and interventions. <http://delawareestuary.org/sciencereports>



PDE Science Team